# REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, AGRICULTURAL RESEARCH ADMINISTRATION, 1946

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UNITED STATES DEPARTMENT OF AGRICULTURE,
*Washington, D. C., September 15, 1946.*

Mr. P. V. CARDON,
*Agricultural Research Administrator.*

DEAR MR. CARDON: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1946.

Sincerely yours,

P. N. ANNAND, *Chief.*

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## INTRODUCTION

The further development of new insecticidal materials and improvements in equipment and methods for their application have continued to receive major emphasis. With the lessening of military requirements for DDT, supplies of insecticides containing this new material became available for civilian use in August 1945. The public immediately showed a tremendous desire to try out this material which they had been hearing so much about. Although it was possible to make definite recommendations for the civilian use of DDT only against a few insect pests, various formulations containing it appeared on the market in rapidly increasing quantities. Suggestions regarding the practical and safe use of this material for various purposes are being made as fast as experimental evidence permits.

Extensive experimentation has been carried on to determine the usefulness of new materials that show promise for the control of agricultural pests, as well as those affecting the health of man and animals and those injurious to stored products and in the home. Advancements have also been made in methods and equipment for applying insecticides and fumigants. Many of the developments resulting from research have been applied to large-scale control projects carried on in cooperation with State and other agencies. Some have aided in simplifying and improving methods used in certifying materials and products that require treatment in order to move under quarantine regulations.

The constant increase of air transportation continues to create problems in protecting the country from importations of new insect pests and plant diseases and in preventing the spread of those already established in limited areas.

Progress made during the year in these and other lines of work carried on by the Bureau is discussed in the following pages. Unless otherwise specified, references to the year 1946 refer to the fiscal year.

The only change in the administrative set-up of major importance during the year was in the leadership of the Division of Insects Affecting Man and Animals. Walter E. Dove, head of that Division for 3 years, resigned on November 1, 1945, to enter private industry. Emory C. Cushing returned on February 1, 1946, to resume direction of the work of this Division, which he had headed prior to his military service.

## RESEARCH INVESTIGATIONS

### DEVELOPMENT OF NEW AND IMPROVED INSECTICIDES CONTINUED

#### DDT TESTED AGAINST MANY INSECTS

Extensive experimentation has been continued to determine practical and safe uses of various formulations containing DDT on different crops for the control of pests against which this material shows promise. In August 1945, when DDT insecticides were first made available

to the general public, a summarized statement containing suggestions for their use by civilians was issued. Over 40,000 copies of this statement were distributed, largely in response to individual requests. As additional information has become available, other statements and publications have been issued to guide the public in the use of this popular new insecticide.

Except against household insects and direct pests of man and animals, such as flies and mosquitoes, few definite recommendations for the use of DDT have been made. Before its general use on many crops can be recommended with safety, much remains to be learned concerning the possible hazardous effects on man and animals of residues on food or forage crops, and of possible detrimental effects of widespread applications on soils, as well as on the natural enemies of certain pests.

### *Fruit Insects*

In the crop season of 1945, as in 1944, DDT gave outstanding control of the codling moth wherever tested. A 50-percent wettable powder appeared to be the most practical formulation, applied as a spray usually at a strength of 1 pound of DDT per 100 gallons of water. At Poughkeepsie, N. Y., a high degree of control was obtained with a nine-application schedule of 5-percent DDT dust, but at Vincennes, Ind., DDT dusts gave much poorer results. In preliminary tests concentrated solutions of DDT, atomized and blown into the trees, were less effective than DDT sprays and caused some injury. At Vincennes DDT sprays with a mean droplet diameter of 2.5 microns gave nearly perfect control of the codling moth, whereas droplets of 25-micron diameter were only half as effective. In the East and Middle West a six-cover spray schedule using 1 pound of DDT per 100 gallons of spray against the first brood and ¾ pound against the second brood, without oil, and with the final application a month or so before harvest, resulted in residues of approximately 7 p. p. m., the present administrative tolerance. Used with oil, DDT in excess of 6 ounces per 100 gallons in six applications during the season usually left residues greater than the tolerance. In the Northwest the residues resulting from comparable programs seem considerably higher.

At Yakima, Wash., mites and woolly apple aphids developed to serious proportions in all DDT-treated plots except when xanthone was included in the spray. Additional evidence was obtained that outbreaks of red spiders and other mites result from the use of DDT because of its high toxicity to their predators. This group of problems is now receiving special attention.

Because of the mite problem, and uncertainties about the status of residues of DDT, this material has not been given unqualified recommendation for codling moth control despite its effectiveness.

Three applications of DDT on apples in the Hudson Valley of New York reduced infestations of the apple maggot from 25 percent to 2 percent.

In extensive field tests DDT, mostly at the rate of 1 pound in 100 gallons of spray, gave excellent control of Japanese beetles on grapes, early apples, peaches, and miscellaneous trees and shrubs. No spray injury was observed, although mites increased noticeably in August. Linden trees sprayed on June 27 were severely defoliated by mites during August. DDT dissolved in xylene and kerosene, 1 pound per

gallon of solution, when applied to various shade trees and ornamentals as a fine mist with a power blower at the rate of 1 gallon per acre, was highly effective in destroying a heavy infestation of adult Japanese beetles and in preventing reinfestation.

A single application of DDT, 1 pound to 100 gallons, on grapes in Ohio, gave effective control of a light infestation of the rose chafer, complete control of grape leafhoppers for the entire season, and control of the grape rootworm. Three applications of DDT were more effective than a lead arsenate-bordeaux-summer oil formulation against the first brood of the grape berry moth.

In Ohio one application of DDT to peach trees 20 days before harvest effected a significant reduction in late-season injury by the oriental fruit moth, and the residues at harvesttime were well under 7 p. p. m. Unfortunately, DDT is highly toxic to the important parasite of this moth, *Macrocentrus ancylivorus* Roh. In South Carolina 1 pound of DDT per 100 gallons of spray again reduced the percentage of the peach crop deformed by sucking bugs. When the trees were sprayed at both petal fall and shuck-off, the proportion of peaches affected was reduced from 40 percent to 6.2 percent. A single application at petal fall was about as effective.

Variable results were obtained with DDT for the control of scale insects on citrus. In Florida DDT did not add to the effectiveness of an oil emulsion against Florida red scale, but DDT emulsions containing fuel oil or xylene, applied in April before the period of build-up, held infestations to a low level as compared with untreated trees.

A single application of DDT to citrus trees in Florida was again found effective in ridding them of the little fire ant, and in preventing reinfestation. An emulsion containing DDT in fuel oil used at the rate of 1 pound of DDT per 100 gallons of water was superior to other formulations.

In Texas DDT gave better control of the pecan nut casebearer than a combination spray containing lead arsenate, nicotine sulfate, and oil, the best previously known treatment. Favorable results with DDT against this insect were also obtained in Florida. DDT also showed promise for control of the pecan weevil.

DDT in several formulations again showed outstanding effectiveness against the pear thrips on prunes in Oregon.

Water-dispersible, or wettable, DDT used at 6 pounds to 100 gallons of water and a dust containing 20 percent of DDT in pyrophyllite applied on fruiting mango trees in Mexico gave highly significant reductions in populations of the Mexican fruitfly.

### *Forest Insects*

Intensive studies were conducted in 1945 to determine what effect the widespread use of DDT over forested areas would have on beneficial insects, fish, and wildlife. The Fish and Wildlife Service of the Department of Interior and interested State and private agencies cooperated in these studies. When as much as 5 pounds of DDT per acre was applied, there was considerable destruction of fish and birds, as well as of practically all insects in the treated area. However, only 1 pound, or less, is required for effective control of important forest pests such as the spruce budworm and the gypsy moth. When only 1 pound of DDT per acre was applied, there was no apparent effect

on the bird population, generally only slight injury to fish and other aquatic life, and only a temporary reduction in the general insect populations. Additional studies are being made in 1946, giving special attention to the effect of DDT on aquatic life and nestling birds.

Aerial application of DDT proved to be extremely effective against the gypsy moth, and in 1946 more than 60,000 acres of infested woodland have been sprayed as part of the control program. Large-scale applications of DDT were also made with a mist blower for control of this insect. (See pages 16 and 17.)

In the spring of 1946 several large test plots were sprayed with DDT from an airplane for control of the white pine weevil, in cooperation with the New York State Department of Conservation. Preliminary observations indicate that effective control was obtained.

In small-scale tests bark beetles that transmit the Dutch elm disease fungus and sucking insects that may transmit the virus causing the phloem necrosis disease of elm were controlled by the use of DDT. Several large experimental plots were sprayed with power machines, using various formulas and dosages. Tests are now under way to determine how many applications per season will be necessary for practical protection. If more than one or two are necessary, the expense may be too great. This work is being done in cooperation with the Connecticut, New Jersey, and Ohio Agricultural Experiment Stations and with city officials in Columbus, Ohio, and St. Louis and Kansas City, Mo.

In 1945 technical supervision was given to a State and privately financed aerial spraying project for control of the hemlock looper in Oregon. About 2,200 acres were sprayed with DDT at a cost of $2.33 per acre and 9,300 acres with lead arsenate at $3.50 per acre. DDT was applied at the rate of 1 pound and lead arsenate at about 9 pounds per acre. Satisfactory control was obtained with both materials.

### *Potato Insects*

In experiments at Houlton and Presque Isle, Maine, conducted in cooperation with the Maine Agricultural Experiment Station, fungicide dusts and sprays to which DDT was added were applied to potato plots. The combination appeared to have no visible adverse effect upon the plants, controlled infestations of Colorado potato beetles and potato flea beetles, substantially reduced the aphid infestations, and appreciably increased yields of potatoes. The aphids involved were the green peach aphid, the potato aphid, the buckthorn aphid, and the foxglove aphid. The fungicidal efficiency was apparently not impaired, since late blight control was good in all treated plots. The DDT aerosol was also effective but was less satisfactory, as it cannot be combined with fungicides and 1 pound of DDT is required per acre as compared with 0.5 pound in DDT emulsion. Tractor-mounted sprayers, on which the booms carried three or four nozzles per row and applied 100 gallons or more of spray per acre, gave better control of aphids than traction sprayers, with two nozzles per row and applying about 75 gallons per acre, although greatly increased yields of potatoes were obtained with both types of equipment.

A dust mixture containing 5 percent of DDT and an emulsion containing 0.5 pound of DDT per 100 gallons were the most efficient formulations in reducing the aphids, but yields of potatoes from plots

treated throughout the season with fungicide sprays containing 0.8 pound of DDT per 100 gallons in a suspension were approximately equal to those obtained when the emulsion was used.

If DDT is included in every spray application throughout the season, the flea beetles and Colorado potato beetles that appear on the young plants will be controlled and it will not be necessary to use an arsenical. Early application should also reach the aphids on the less dense foliage before they build up to appreciable numbers.

In applying DDT dusts or sprays it is important to arrange the nozzles in such a manner that the insecticide reaches the under side of the leaves where most of the aphids are located, particularly for the lower leaves.

In plots where thorough applications of sprays were made regularly beginning about the 1st of July, the few aphids present were scattered generally over the leaves and not many of them developed to the winged stage. Winged aphids, however, moved into the plots during August in approximately the same numbers as into the check plots. Although insecticide treatments may be of value in reducing early season spread of leaf roll by wingless aphids crawling from unrogued potato plants to nearby healthy plants, they probably cannot be expected to reduce the more serious infection caused by aphids moving into the treated fields later in the season. To reduce the number of such dispersants of leaf roll, the insecticide would need to be applied universally throughout an area. Delaying the development and consequent movement of these aphids might permit a corresponding postponement of the harvesting date to avoid infection by leaf roll. Insecticide treatments can be expected to contribute to the increased production of seed potatoes with low leaf roll infection only if accompanied by other recommended practices.

*Cereal and Forage Crop Insects*

Treatment of soil with DDT has shown promise of becoming a practical means of controlling the white-fringed beetle. DDT was found to be effective and practical for use against the vetch bruchid and alfalfa seed insects without adverse effects on honeybee populations when properly used. Infestations of leafhoppers, the alfalfa weevil, thrips, and aphids in seed alfalfa were also controlled with DDT. Flake talc was observed to be the most suitable diluent in DDT dust mixtures for control of the European corn borer. DDT micronized on fuller's earth in spray suspensions gave the highest control of the corn borer of any material tested. Corn borers were controlled with DDT spray or dust when the number of applications was reduced from four to three, or even two, with either ground or airplane equipment, and it is possible that the insecticidal control of this insect on canning and field corn may thus become practical.

Oil sprays containing from 0.5 to 1 percent of DDT were very promising for control of the corn earworm in corn grown for seed, and possibly in canning and market sweet corn, when injected into or atomized onto the silks. DDT showed promise in foliage treatments for the control of leafhoppers on peanuts and alfalfa, thrips on seedling peanuts, the corn flea beetle on seedling corn, and in soil treatments for control of spotted cucumber beetle larvae attacking peanuts and soil-inhabiting stages of the corn flea beetle. A 1-percent DDT suspension

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proved satisfactory for spraying railway boxcars intended for carrying flour, when 1 gallon of spray was used per car. DDT was found to be the most effective material for treating interior walls of wooden farm granaries to reduce insect infestations; it may be applied as a solution, an oil emulsion, or a water suspension. Experimental treatments of flour and grain sacks and food-package wrappings in various ways with DDT and a related compound gave excellent protection of the contents and considerable promise that a safe and commercially practical way of applying such insecticides may be found.

*Cotton Insects*

Extensive tests to obtain further information on the effectiveness of DDT against various cotton insects were carried on in 1945 in cooperation with the State Agricultural Experiment Stations and other Federal, State, and local agencies.

At Florence, S. C., 10-percent DDT dust was found to be more effective against hemipterous insects on cotton than any other insecticide tested.

At Tallulah, La., dusts containing 2.5, 5, and 10 percent of DDT were more effective against the tarnished plant bug than calcium arsenate or sulfur. In field tests 5- and 10-percent DDT dusts were more effective against the tarnished plant bug and the rapid plant bug than calcium arsenate or mixtures of calcium arsenate and 2.5-percent DDT. DDT was not nearly so effective as calcium arsenate against the boll weevil. Calcium arsenate alone gave an average increase in yield over the untreated checks of 890 pounds of seed cotton per acre, calcium arsenate containing 2.5-percent DDT an increase of 760 pounds, 10-percent DDT dust an increase of 260 pounds, and 5-percent DDT dust an increase of 100 pounds per acre.

At Waco, Tex., DDT in atomized oil sprays and in xylene emulsions gave a quicker kill of bollworms than when applied as a dust. Dusts containing 5 and 10 percent of DDT gave better bollworm control than 2.5-percent DDT or cryolite-sulfur dust. Fused DDT-sulfur dust averaged slightly better than simple DDT-sulfur dust mixtures in controlling bollworms and cotton flea hoppers and increasing the yield of cotton. DDT-sulfur mixtures gave outstanding flea hopper control in field experiments in 1945, and during May and June of 1946 farmers in the coastal area of Texas obtained excellent control of cotton flea hoppers with a 5-percent DDT dust mixture. Cotton aphids increased more following the use of DDT-calcium arsenate mixture than following the use of either material alone. The addition of 1 percent of nicotine to DDT mixtures prevented aphid build-up.

In the lower Rio Grande Valley phytotoxicity tests were conducted with 123 spray formulations in an effort to find an inexpensive carrier for DDT that was not injurious to the cotton plant when applied at the rate of 3 to 9 gallons of spray per acre. The most satisfactory formulation developed consisted of DDT dissolved in xylene with a small quantity of Triton X–100 (an aralkyl polyether alcohol) or Igepal CA (condensation product of ethylene oxide and an alkylated cresol) added as an emulsifying agent.

In the Presidio and El Paso Valleys reductions of 65 to 95 percent in the seasonal pink bollworm populations were obtained from the ap-

plication of 7.5 to 15 pounds of DDT per acre either in sprays or dusts, the degree of control increasing with the quantity of DDT used. An experiment at Presidio under a large screen cage indicated that early applications of DDT commencing about the time the cotton started to square gave slightly better control than applications made later in the season. Five weekly applications of 10-percent DDT at the rate of 15 pounds per acre, beginning May 20, and five similar applications beginning July 9, reduced the bloom infestation 80 percent, and the pink bollworm population did not build up sufficiently to cause boll damage until September 1.

In the large-scale experiments in the Presidio Valley DDT did not control the red spider and aphids on cotton, but populations did not build up sufficiently after nine applications of DDT to necessitate control measures against these insects. Although this material is not recommended for control of the cotton leafworm, when it was applied at weekly intervals against other insects it checked the leafworm to the extent that no appreciable damage was caused. A reduction in stinkbugs, plant bugs, and other injurious insects, as well as in ladybird beetles and other beneficial insects, was noted.

The El Paso Valley plots were sprayed five times with 2.5 gallons of emulsion containing 1.25 pounds of DDT per acre application, and they had only 7.3 pink bollworms per 100 bolls as compared with 92 pink bollworms in the untreated check plots. Only slightly better results were obtained by increasing the treatment to 5 gallons of emulsion containing 2.5 pounds of DDT per acre-application. DDT-sulfur mixtures reduced the populations of sucking bugs below the point where they caused economic damage to cotton. Large-scale airplane dusting tests with DDT-sulfur mixtures were conducted for the control of sucking bugs, beginning about the time the first bolls became susceptible to pink bollworm attack and continuing at weekly intervals until four applications had been made. In these fields the seasonal build-up was limited.

In Arizona the plant bugs and stinkbugs invaded the cotton fields in damaging numbers about 2 weeks earlier in 1945 than usual. Large acreages were dusted with the standard mixture containing 7.5 percent of paris green in sulfur, generally with good results. Some of the growers used a sulfur mixture containing 15 percent of paris green, which gave even better results against the injurious cotton insects, but was very toxic to honeybees. DDT mixtures were tested on a large scale for the second year in comparison with other insecticides, and in every case proved more effective in increasing the yields. The gains from using 5 percent of DDT, 75 percent of sulfur, and 20 percent of pyrophyllite ranged from 283 pounds of seed cotton per acre at Marana to 972 pounds at Litchfield Park. The gains from the standard paris green-sulfur mixture in similar experiments ranged from 27 to 243 pounds of seed cotton per acre. Five percent of DDT in sulfur or pyrophyllite was also very effective in controlling the beet armyworm and the cotton leaf perforator.

A serious outbreak of the bollworm threatened about 1,500 acres of cotton in the Sahuarita district south of Tucson, Ariz., but was controlled with heavy applications of calcium arsenate; however, records made in experimental plots indicated that 5-percent DDT was more effective than calcium arsenate for bollworm control.

*Pests Affecting Man*

Studies on the residual effectiveness of DDT against mosquitoes and flies were continued. A large-scale experiment in Mexico was undertaken in cooperation with the Rockefeller Foundation and the Mexican Federal and State health services to determine whether spraying the interior walls and ceilings of buildings with a 5-percent DDT-oil solution would protect people from the malaria-carrying mosquito. Entomological results obtained to date indicate that the adult and larval incidence can be greatly reduced by treating the interiors of all the houses with this spray.

In Florida satisfactory control of salt-marsh mosquito larvae was obtained from 0.2 to 0.8 pound of DDT per acre when applied from the ground and from 0.5 pound per acre when applied from the air. In a wooded Florida swamp sprays with droplets 75 to 100 microns and those with droplets 300 microns in diameter were equally effective against the common malaria mosquito. The coarse sprays were effective largely as spray residues, whereas the fine sprays had both a residual and a contact effect.

In cooperation with the United Nations Rehabilitation and Relief Administration a large number of tests on malaria control were made with DDT emulsion concentrates in central Europe.

Satisfactory control of mosquito larvae was obtained in 11 areas along the Columbia River that were sprayed with DDT from 2 to 51 days before the annual flood occurred. Oil solutions and emulsions were applied to the egg beds at the rate of 1 to 2 pounds of DDT per acre.

Delegates to the International Monetary Conference held in Savannah, Ga., were protected from sand flies by applications of DDT in various formulations. A 5-percent DDT solution was applied to the window and door screens of their headquarters. Screen hoods treated with this solution were fitted over the street lights, and DDT suspensions were applied to the outside walls of the hotel, swimming pool, and shrubbery. The 100-car garage and other buildings were sprayed with a DDT emulsion. Airplane applications of DDT solutions were made to cover the marshland, river front, and wooded areas, and DDT fogs were generated over the entire area. It was estimated that 90 percent control was effected.

DDT is proving effective against some species of ticks. Good control of the lone star tick was obtained on Bull's Island, S. C., when dusts or sprays were applied from ground and aircraft. These tests were made in cooperation with the Fish and Wildlife Service, which has reported that no injurious effects on wildlife have been observed.

A field test in Wilmington, Del., showed the benefits of treating dumps with 5-percent DDT sprays for controlling houseflies.

*Livestock Pests*

Tests against the ectoparasites of livestock clearly demonstrate the efficacy of DDT in controlling many of the insect pests that take a heavy toll from the meat- and milk-producing industries of the Nation. Approximately 100,000 head of livestock have been treated with DDT preparations to determine the most effective and economical dosages.

The most effective practical dosage for all parts of the country has not yet been worked out, but the tests indicate that a water suspension containing 1.5 percent of DDT applied at the rate of about 1.5 pints per animal is effective against horn flies for at least 3 weeks. In cooperative tests conducted in Kansas, treated cows on pasture gained 42 to 51 pounds and calves from 47 to 70 pounds more per animal than untreated cows and calves during a test period of approximately 3 months. On the basis of these tests, the application of each pound of DDT was estimated to produce from 1,200 to 2,300 additional pounds of beef.

DDT suspensions were found to be more desirable than solutions and emulsions in spraying dairy barns for the control of houseflies. The most effective dosage yet developed is 1 gallon of a spray containing 2.3 percent of DDT per 300 square feet of surface.

DDT and another chemical, benzene hexachloride, have shown more promise than any materials heretofore used for the control of all species of cattle lice. Both these materials appear to be capable of eradicating cattle lice with one treatment, which has not been possible with the older remedies.

Excellent results in the control of the Gulf coast tick were obtained by applying to the ears of cattle smears containing 5 percent of DDT, 47 percent of rosin, 33 percent of Hercolyn (hydrogenated methyl abietate), and 15 percent of dibutyl phthalate. Experiments indicate that this mixture will kill the Gulf coast tick and prevent reinfestations over a period of 3 to 6 weeks.

In preliminary tests DDT appeared as effective against the cattle tick as the standard arsenical dips.

*Clothes Moths*

Since 1942 this Bureau has been cooperating with the Defense Supplies Corporation of the Reconstruction Finance Corporation to prevent undue moth injury in millions of dollars' worth of foreign wool stored in the United States under Government supervision. This wool came to the United States in compressed bales weighing from 300 to 1,200 pounds and was stored from 2 to 5 bales high in large warehouses. During the past year over 500,000 bales were sprayed with DDT. Because of the manner in which the bales were stored, not more than 6 to 10 percent of the total bale surface was treated. DDT was applied by means of 5-gallon pressure hand sprayers at the rate of about 1 gallon of 1-percent and 0.25-percent DDT, both as oil solutions and as water-dispersible sprays, to about 10 square feet of surface. As the season progressed there seemed little choice between the oil solution and the water-dispersible preparation, but the 0.25-percent DDT was not so satisfactory as the stronger spray. The treatments were completed early in the summer. From then until fall exceedingly few living adult moths could be found, but many thousands of dead moths were on the floor surrounding the bales. Although more work should be done, particularly with American-bagged wool, before DDT sprays can be fully evaluated, the results have been so convincing that some wool merchants are already using them as a routine control measure.

Mothproofing treatments of animal fibers are usually applied after they have been manufactured into fabrics. This leaves them without protection from the time they are sheared until they are consumed

in the weaving process. This period of storage often lasts several years, during which time serious damage can take place. It does not seem practical to treat fleeces after they are removed from the animal and before they are placed in storage. From preliminary tests it appears that fleeces from animals dipped in DDT preparations for louse and tick control and sheared a few days later are rendered mothproof. In May 1946 fleeces from animals dipped in solutions containing DDT were still as moth resistant as when they were first tested after shearing in 1944. This method of protecting mohair during the usual period of warehousing offers a new and practical solution to the problem.

### *Cockroaches*

In a cooperative experiment with the United States Army it was shown that a 5-percent solution of DDT in deodorized kerosene could be used to eradicate a heavy infestation of German cockroaches. The experiment was conducted in a large hospital where the kitchens, food-preparation rooms, and other quarters were treated.

## CHEMICAL INVESTIGATIONS ON DDT

Many problems connected with the insecticidal use of DDT were investigated. Study of the solubility of DDT in kerosenes from different sources showed naphthenic-base kerosenes to be better solvents than those of paraffinic base. Chemical investigation of the effect of ultraviolet light and sunlight on DDT indicated that technical and pure DDT, either undiluted or mixed with various inert powders, undergo very little decomposition. When DDT dissolved in an organic solvent is irradiated, however, the decomposition is greater, the degree depending upon the solvent used. A number of DDT emulsions were investigated as to stability and plant injury. Physical properties of various DDT dusts were studied and various methods of grinding DDT mixtures were investigated. Specifications were drafted for dusts containing 10 percent of DDT in clays. Storage tests were made with the free-flowing and water-dispersible DDT previously developed in this Bureau. Prospective diluents for DDT were examined. The colorimetric method for determination of DDT was refined and modified so that it can now be applied to the determination of minute deposits in various materials, including milk, meat, and fats. A study of possible absorption of DDT from soil into the tissue of plants did not reveal significant amounts of DDT in the plants in any case. The rate of loss of DDT deposits by weathering from apples in the field was found to be no less than with lead arsenate or cryolite.

## BENZENE HEXACHLORIDE PROMISING AGAINST SOME PESTS

In experiments at Waco, Tex., in 1945 high concentrations of benzene hexachloride killed the boll weevil and the cotton leafworm more quickly than did calcium arsenate. Control of the cotton flea hopper, the tarnished plant bug, and the southern green stinkbug was equal to or better than that obtained with DDT. Against the cotton aphid benzene hexachloride was more effective than nicotine dusts. However, the residual effect of this material on cotton in the field was not equal to that of calcium arsenate or DDT.

In Arizona benzene hexachloride gave very promising results in preliminary tests against several species of stinkbugs and plant bugs on cotton. In one small field test 1 percent of the gamma isomer in pyrophyllite gave a computed gain of 750 pounds of seed cotton per acre. The dust was applied four times during the season at the rate of 20 pounds per acre.

In tests at Tallulah, La., benzene hexachloride was more effective than DDT against boll weevils and tarnished plant bugs. However, calcium arsenate produced the highest boll weevil mortalities. Both weevils and tarnished plant bugs were killed by benzene hexachloride vapor and also by contact. The contact and fumigant actions were much faster on tarnished plant bugs than on boll weevils.

In field-plot tests in 1946 in cooperation with cotton growers in the lower Rio Grande Valley of Texas for the control of thrips on seedling cotton, 5, 1.25, and 0.31 percent of gamma-benzene hexachloride in sulfur gave at least as good control as 5 percent of DDT in sulfur.

At Stoneville, Miss., on cotton plants treated with sulfur dust containing 5 percent of gamma-benzene hexachloride at the rate of 5 pounds per acre, the average thrips population 24 hours later was 0.25 per plant as compared with 4.15 on untreated plants. Plant injury by this mixture was negligible.

At Florence, S. C., 10-percent gamma-benzene hexachloride was used against thrips and red spiders on cotton. This material was apparently 100 percent effective against thrips within 24 hours. The reduction in the red spider population was not so striking, but after 12 days there was a reduction of 96 percent. Observations indicated that the material had to come in contact with the red spiders to be effective. It caused considerable injury to the young terminal growth of cotton in the greenhouse and to cotton in the presquare stage in the field. However, the cotton appeared to outgrow this injury in a short time, and it seemed doubtful that any economic loss had been caused.

Small-scale preliminary tests of benzene hexachloride have been conducted against the codling moth, the Japanese beetle, the plum curculio, sucking bugs that cause deformed peaches, the pear thrips, and the pear psylla. In laboratory tests at Beltsville, Md., it showed promise for control of the codling moth, but at Vincennes, Ind., it was less effective in the field than DDT, failed to control orchard mites, and seriously affected the taste of Golden Delicious apples harvested about 3 weeks after its application. Against the pear thrips it was less effective than DDT, and against the pear psylla less effective than nicotine. Very small quantities were highly toxic to Japanese beetle grubs in the soil, and encouraging results were obtained on the plum curculio.

In Mexico no reduction in populations of the Mexican fruitfly in fruiting mango trees was obtained with a high concentration of water-dispersible benzene hexachloride.

Tests have indicated that benzene hexachloride is less effective than DDT against the group of elm insects suspected of transmitting the elm virus disease organism.

In experimental trials benzene hexachloride was very effective against eggs, larvae, and adults of white-fringed beetles, and dust mixtures of this insecticide in talc showed some promise against the sugarcane borer. Benzene hexachloride also gave more favorable

preliminary results than DDT in field tests when applied for grasshopper control.

Laboratory tests with benzene hexachloride revealed it to be the most toxic insecticide known against housefly adults and larvae, being about 8 to 10 times as toxic as DDT. It was found to be extremely toxic to German roaches, more so than pyrethrum, which had always been considered outstanding in this respect. It was also more toxic than DDT to the following insects that attack crops: Large milkweed bug, melon worm, southern armyworm, southern beet webworm, alder flea beetle, imported cabbageworm, armyworm, and corn earworm.

In laboratory tests benzene hexachloride was toxic to fourth-instar larvae of the mosquitoes *Aedes vexans* (Meig.) and *A. lateralis* (Meig.).

In preliminary field tests benzene hexachloride has been found effective in controlling the black-legged tick and the common chigger.

The results reported herein must be regarded as preliminary. Before benzene hexachloride can be recommended to the public, further experimental work is required. Little is yet known of its limitations, including its toxicity to animals, to plants through the soil, and to bees and other beneficial insects.

### INSECTICIDES DERIVED FROM PLANTS STUDIED

In the investigation of the active constituents of pyrethrum, partial synthesis of the pyrethrins and cinerins was carried out. The total synthesis of the cinerins also has been partly completed. Tests against houseflies with these compounds indicated that the toxicity of pyrethrin I is about 1.5 times that of cinerin I and 4 times that of pyrethrin II, and that cinerin I is about 4 times as toxic as cinerin II.

The essential oil of *Eugenia haitiensis* was found to be toxic to houseflies and mosquitoes and to have a considerable knock-down effect. The active fraction of this oil was identified as cineole.

In tests at Waco, Tex., heavy dosages of undiluted *Ryania* dust gave fair control of the bollworm on cotton, although the kill was much slower than when 5 percent of DDT in pyrophyllite was used. *Ryania* was not effective against the boll weevil or the cotton aphid. Sabadilla failed to control any of these cotton pests.

In preliminary experiments dust mixtures of sodium fluosilicate or *Ryania* in pyrophyllite showed promise in control of the sugarcane borer.

Laboratory tests with yam bean, *Erigeron* roots, and many synthetic organics were completed. All these materials were found to have little or no toxicity to the economic insects used in these tests.

Cooperative tests on samples of rotenone-bearing roots from the Puerto Rico Agricultural Experiment Station showed that in some plants certain other constituents of the roots besides rotenone were effective in killing houseflies and Mexican bean beetles.

In field experiments in Mexico small amounts of rotenone in emulsive spray oils greatly increased their effectiveness against the citrus blackfly.

Experiments in 1945 at Tallulah, La., again showed that injurious infestations of cotton aphids are prevented by adding 2 percent of nicotine to alternate applications of calcium arsenate or 1 percent of nicotine to all applications. In experiments conducted during the last

7 years calcium arsenate gave an average increase over the checks of 126 pounds of seed cotton per acre, while combinations of calcium arsenate and nicotine gave an average increase of 365 pounds. Many cotton growers in Louisiana and Mississippi are now following the calcium arsenate-nicotine program for control of boll weevils and cotton aphids. It has also been discovered that nicotine is more effective against aphids in a 2:1 mixture of calcium arsenate and lime than in calcium arsenate alone. The different mixtures containing the alkaloid nicotine that have been compared with nicotine sulfate have proved to be equally effective. Nicotine mixtures are effective when applied in early morning, late afternoon, and at night, but often are not effective when applied during midday hours. The average gain in seed cotton in the plots at Tallulah that received the standard calcium arsenate treatment for boll weevils was 479 pounds in 1945, as compared with an average of 306 pounds during the last 26 years.

At the Florence, S. C., laboratory 1 percent of nicotine was more effective than 0.75 percent of rotenone when mixed with calcium arsenate for the control of the cotton aphid, but when mixed with basic copper arsenate the rotenone was more effective.

Of various organic solvents tested in the extraction of anabasine from *Nicotiana glauca*, ethylene chloride was found to be one of the best.

### OTHER SPRAYS OR DUST MATERIALS TESTED

More than 7,000 preliminary tests were made on new compounds, on improved combinations of insecticides and adjuncts, and on commercial samples. Some toxicity to one or more species of insect pests was shown by 72 of these materials. Of 223 samples tested for synergistic action with pyrethrins against houseflies, 22 showed such action.

About 150 organic compounds were synthesized for testing as insecticides, synergists for pyrethrum, or insect repellents.

Tests of the new insecticide designated as 1068 showed it to be less toxic than DDT to the group of insects suspected of transmitting the elm virus disease organism. In laboratory tests this material and two other new insecticides, 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane (a derivative of *p,p*-DDT, designated as TDE) and a chlorinated camphene, were less toxic than DDT to fourth-instar larvae of *Aedes vexans* and *A. lateralis*. The chlorinated camphene, however, was found to equal DDT in toxicity to some household and crop insects. It showed sufficient promise to warrant recommendation for field testing.

Another material, hydroxymethylflavan, is the most effective material yet found for the control of chiggers in grass and woodlands.

In spray treatments for pear psylla control, petroleum oil (Saybolt viscosity 100 sec.) was more effective when applied prior to egg laying than after eggs had been deposited. Dinitro-*o*-cresol seemed to be the best of the dinitro compounds tested as ovicides for the psylla, but blossom and leaf injury occurred on certain plots owing to the advanced development of the plants at the time the sprays were applied.

Several commonly used fungicides prevented insect infestation of seed grain from the outside when added at the rate of 0.2 percent or less of the weight of the grain. When 1 to 3 percent of DDT was incorporated with the fungicide, infestation already present in the

grain was also controlled. Silica gel mixed with seed wheat at 0.2 percent by weight gave excellent protection against the rice weevil and the confused flour beetle.

A mixture containing pyridine in a nondrying adhesive has been found promising against the ear tick infesting cattle. The use of this tickicide in the spring and fall in combination with a treatment of equal parts of lubricating oil and kerosene sprayed around and under salt troughs gave excellent control.

Research has been continued to develop substitutes for diphenylamine and turkey red oil for treatment of screwworms. Diphenyl and chlorophenoxathiin are new materials showing promise as substitutes for diphenylamine, and Triton X–300 (sodium salt of an alkylated aryl polyether sulfate) may be used in place of turkey red oil.

About 2,000 samples of insecticides and products containing insecticidal residues were analyzed for various divisions in the Bureau.

### INSECTICIDES AND REPELLENTS FOR MILITARY USE

Investigations on insecticides and repellents for use by the armed forces, conducted under a transfer of funds from the Office of Scientific Research and Development, were continued until October 31, 1945. Since that time the work has been reduced but continued under funds transferred from the Office of the Surgeon General of the Army.

Studies on human lice have resulted in two outstanding developments. (1) It has been found that certain individuals among various breeds of domestic rabbits serve as well as man as a source of food for rearing laboratory colonies of body lice. This discovery makes it possible to maintain, at moderate expense, a colony for continued investigations of improved means of controlling this important insect. (2) Tests of more than 6,000 organic compounds as insecticides to control human lice showed 5 to be more toxic than DDT. Further studies eliminated 4 of these materials, but the fifth, a chlorinated camphene of American manufacture, appears to be superior to DDT, both as an ingredient of louse powder and for impregnation of clothing.

During the year screening tests of more than 7,500 chemicals as mosquito repellents for skin applications have been completed, and 8 chemicals have been found to give over 5 hours' protection against the bites of yellow-fever mosquitoes. These materials are now being tested for their toxicity to man before they are recommended for use.

Screening tests of chemicals for use as miticides were also completed during the year. Of about 8,000 materials tested, 229 were shown to be equal or superior to benzyl benzoate in toxicity to mite larvae. Two of these materials when impregnated in clothing remained effective after 7 to 11 washings, whereas benzyl benzoate, which was used extensively against mites causing scrub typhus during the war, failed after 2 to 4 washings.

A practical test on the control of a scabies outbreak in American troops in Italy demonstrated that the NBIN formula—benzyl benzoate 68 percent, DDT 6 percent, benzocaine 12 percent, and Tween 80 (polyoxyalkylene derivative of sorbitan monooleate) 14 percent—is effective against the mite causing this disease. This concentrate is diluted 1 part to 5 parts of water and applied with a sponge or by hand. This treatment has been widely adopted by American dermatologists for civilian use.

In the laboratory the following synthetic chemicals were found to be equal to or better than DDT as anopheline larvicides: 1,1-Dichloro-2,2′-bis(*p*-chlorophenyl)ethane; 1-trichloromethyl-2,2′-methylene-bis-(6-bromo-4-chlorophenol); and 1-trichloromethyl-2,2′-methylene-bis-(4-chloro-6-nitrophenol).

### FUMIGANTS

In tests of new grain fumigants 5 percent of ethylene dibromide in various combinations with carbon tetrachloride, ethylene dichloride, and carbon disulfide protected wheat stored in steel bins and wooden farm granaries from insect infestation, when used at dosages of 2 to 3 gallons per 1,000 bushels. A mixture of acrylonitrile 14 percent and carbon tetrachloride 86 percent at a dosage of 2 gallons per 1,000 bushels gave excellent results in wheat stored in wooden farm granaries, and mixtures of 10 percent of several nitriles in carbon tetrachloride at 1 gallon per 1,000 bushels gave excellent control of insects in wheat stored in steel bins. A very heavy infestation of stored-grain insects in farm bins 2 years ago was reduced to a negligible amount and the bins kept free from reinfestation by fumigating them once a year in August with the 3:1 mixture of ethylene dichloride and carbon tetrachloride at 6 gallons per 1,000 bushels of grain.

In a laboratory test of several materials used to destroy plum curculio larvae and pupae in the soil, ethylene dibromide, at a comparatively low strength, was the most effective, and gave almost complete control.

Ethylene dibromide was found generally to be much more effective than ethylene dichloride in various formulations as dips for eggs, larvae, and pupae of the Japanese beetle in soil masses and plant balls, and for surface applications to soil plots containing larvae and pupae. However, more information on plant tolerance is needed before it can be generally recommended for quarantine treatments. Ethylene dibromide also showed promise as a fumigant for adult beetles.

At Fresno, Calif., a mixture of equal parts of acrylonitrile and carbon tetrachloride was found to be 100 percent effective in individual-package fumigation when used at the low dosage of 0.5 ml. per 30-pound solid-fiber case of raisins. For the control of the grape phylloxera, dichloroethyl ether emulsion containing DDT, injected into the soil around grapevines, showed promise in a small preliminary test.

### TREATMENTS FOR TERMITES AND WOOD PRESERVATION

Approximately 150 buildings at Fort Bragg, N. C., and a number at Camp Shelby, Miss., have been given soil-poison treatments against termites on an experimental basis in cooperation with the United States Army Corps of Engineers. It is estimated that expenditures for control and repairs as a result of termite damage will run into many thousands of dollars. At Camp Shelby the cost of minimum repairs to one building alone was $500. In a soil-poison experiment in the Canal Zone begun 3 years ago, sodium arsenite is by far the most efficient material under test. No failures have occurred in 50 plots treated with this chemical. Pentachlorophenol and orthodichlorobenzene have also given good results.

Records have been made on the condition of sections of trees that were treated 5 and 10 years ago with preservatives by injection into the sap stream. These sections had been installed in service tests in

different parts of the South. Much of this wood treated with zinc chloride, sodium arsenite, copper sulfate, and ammonium bifluoride is still in a sound condition. This information will be of particular interest to the farmer who faces the problem of mantaining his fences and no longer has cedar and locust posts available.

In experiments conducted in cooperation with the Louisiana State Highway Department and a commercial company, mahogany plywood panels brush-treated with copper paint such as is used on Navy PT boats, plastic paints, or Navy formulation 16–X resisted attack by marine borers and fouling organisms for 7½ months. Approximately 40 other materials that were tested failed.

### PHYSIOLOGICAL AND TOXICOLOGICAL EFFECTS OF INSECTICIDES STUDIED

The initial phase in an investigation of the mode of action of insecticides, which consisted of certain studies on arsenicals, was completed. This study was followed by research to determine the relation between concentration of cyanide poison and survival time of treated insects. In these experiments differences in the symptomatic pictures evoked by the two poisons were noted. Whereas the arsenical-treated insects pass continuously through successive symptomatic stages to death, without partial or complete recovery, the cyanide-poisoned insects appear to recover, at least partially, after the symptoms have appeared, but later die from the effects of the cyanide. Unlike the arsenicals, the cyanides used produce not only a lethal but also a narcotic effect upon the insects. The relation between concentration of DDT and survival time of treated insects was also determined.

## DEVICES AND METHODS FOR APPLYING INSECTICIDES FURTHER DEVELOPED

### AERIAL SPRAYING

Aerial spraying equipment for use in controlling forest insects, particularly defoliators, is being developed in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering. Studies on the formulation of DDT sprays, the determination of the physical properties of sprays required for effective deposits, and the behavior of sprays when released from aircraft are being conducted at the Agricultural Research Center, Beltsville, Md. The most difficult problem encountered thus far has been to obtain a uniform deposit of insecticide over a treated area. Practical tests with different types of equipment, spray formulas, and dosages have been conducted in forests and forest plantations for the control of the spruce budworm, the gypsy moth, the white-pine weevil, pine sawflies, the Saratoga spittle bug, and the pine tip moth. Special attention has been given to tests against the spruce budworm in New York because of the current threat of a widespread outbreak in the spruce-fir forests of the Northeast. All these tests were conducted in cooperation with State or Federal agencies. Frequently the States supplied materials and this Bureau the machines and technical supervision.

In Hawaii caged melon flies were exposed in the field to 5 percent of DDT in oil dispersed by airplane by the Navy at the rate of 0.4 pound to the acre. No mortality resulted which could be attributed to the

DDT. Field populations of melon flies were slightly depressed for a short time. Other aerial applications of DDT are discussed under the section DDT Tested Against Many Insects.

### MIST-BLOWER APPLICATIONS

Through the cooperation of the Connecticut Agricultural Experiment Station and certain commercial concerns, marked progress has been made in the development of mist blowers for applying concentrated sprays from the ground. Finely atomized sprays may be effectively blown vertically up to 100 feet and horizontally over 600 feet. Nozzle assemblies have been developed which will disperse most insecticides and fungicides as solutions, emulsions, or suspensions. The widespread interest of entomologists and spray-equipment manufacturers in this new method is indicative of revolutionary changes in power spraying equipment.

Tests of concentrated sprays applied with blower equipment to control the pear psylla indicated that nicotine alkaloid solutions in kerosene killed 92 to 96 percent of the adults present. Nicotine sulfate was less effective than nicotine alkaloid when used in a concentrated water solution. Applied with blower equipment, concentrated sprays of DDT, pyrethrum, or benzene hexachloride were not so effective as the nicotine alkaloid.

### AEROSOL FORMULATIONS AND EQUIPMENT

Work on the use of aerosols in the control of insects on vegetable crops was continued in cooperation with the Agricultural Experiment Station of the University of Maryland. DDT was used with various solvents and propellants. Mixtures that do not injure plants were developed for field and greenhouse use, and apparatus for applying such aerosols were tested against thrips, aphids, and leafhoppers.

For field use the most satisfactory aerosol contained 5 percent of DDT, 5 percent of cyclohexanone, 5 percent of methylated naphthalene, 35 percent of acetone, and 50 percent of propellent gas, usually methyl chloride. In some cases 0.5 percent of propylene oxide was included to prevent corrosion of the storage tank. The high percentage of the less efficient acetone solvent was used primarily to increase the particle size of the aerosol in order to obtain good coverage under field conditions. As the large particle size is not necessary indoors, very little acetone is required in aerosols for greenhouse crops. One of the most satisfactory formulas tested in the greenhouse contained 5 percent of DDT, 10 percent of methylated naphthalene, 5 percent of acetone, and 80 percent of Freon–12 (dichlorodifluoromethane).

Since the pressure in the dispenser varies with the temperature, it may not give satisfactory distribution of the aerosol in the field below 50°–55° F. At 70° the pressure in the dispenser is about 38 pounds per square inch and the release of the aerosol at this pressure gives satisfactory coverage of the plants.

In large-scale field tests a 5-percent DDT aerosol at a dosage of 10 pounds per acre gave satisfactory control of the pea aphid at temperatures between 55° and 84° F. and resulted in substantial increases

in yield of peas. The dispenser was an inverted pan 24 feet long, 3 feet wide, and 6 inches deep, to which oil-burner nozzles were connected by means of copper tubing. It was supported on bicycle wheels and attached to a light pick-up truck, which traveled through the fields treating the peas at the rate of 12 acres per hour. The cost of materials ranged from $1.75 to $2.25 per acre.

Although the aerosols were somewhat inferior to sprays containing DDT emulsion, the small difference in control is offset by the lightness and simplicity of equipment and the rapid rate of application.

The DDT aerosol applied to fields of onions in 1945 at a dosage of 20 pounds per acre was effective against the onion thrips but slightly less effective than DDT dust mixtures or an emulsion containing DDT. In small-plot experiments this aerosol was more effective than the dusts or the emulsion. In commercial greenhouses in 1946 this aerosol gave outstanding control of the onion thrips on cucumbers, being more effective than any methods formerly employed for the control of this pest. It was applied with a knapsack dispenser, consisting of a tank of 5- or 10-pound capacity from which a flexible hose led to a short spray rod and nozzle, with which the aerosol could be directed into the air over the plants at the rate of 5 gallons per hour. Only 25 minutes was required for one man to treat an acre of greenhouses with 10 pounds of aerosol.

The six-spotted leafhopper in field plots of lettuce maintained by the Bureau of Plant Industry, Soils, and Agricultural Engineering was controlled by applications of DDT aerosol at 10 pounds per acre at intervals of 7 to 10 days during May and June. In 1945 aster yellows disease transmitted to the lettuce by the leafhoppers was reduced from 12 percent infection in the check plots to 1 percent in those treated with aerosol and in 1946 from 72 percent in the check plots to 11 percent in the treated plots. In plots treated with 20 pounds per acre of 5-percent DDT dust 22 percent of the plants were diseased. No other insecticides have been satisfactory in reducing this disease on lettuce.

During the 1945 season tests were made of a number of DDT formulations in which methyl chloride was the propellant. During the 1946 season the methyl chloride is being replaced by mixtures of Freon-11 (trichlorofluoromethane) and Freon-12 because of their lower toxicity to man. Work on the development of aerosol formulas and equipment for use on aircraft is in progress in cooperation with the United States Public Health Service. Formulas containing larger percentages of pyrethrum than those now commonly used are being tested. Aerosol formulations made with pure pyrethrins have been compared with those containing commercial 20-percent pyrethrum extracts. Some further work has been done with combined germicidal and insecticidal aerosols. The Freon-insoluble material in pyrethrum extracts from different commercial sources has been determined, and found to range from 0.1 to 3.8 percent. The particle size of aerosols obtained with several types of nozzles has been measured. The use of lower-pressure aerosols is being studied.

Field tests were made in the Southwestern and Western States in the fall of 1945 and spring of 1946 against various truck-crop, cereal and forage, cotton, livestock, and fruit insects to explore the possible use of heat-generated aerosols for their control.

In studies relative to treatments for commodities regulated by the Japanese beetle quarantine, emphasis was placed on the disinsectization of airplanes by use of aerosols. The effectiveness of several formulas against adult beetles was determined in laboratory tests followed by practical tests in various types of military aircraft.

### FLAME CULTIVATORS TESTED AS INSECTICIDE DISTRIBUTORS ON COTTON

The use of flame cultivators by cotton growers is increasing. At Stoneville, Miss., studies are being conducted in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the State Agricultural Experiment Station to determine whether a practical method of insect control can be developed for use in connection with the flame cultivators. An attachment has been devised to feed liquid insecticides to the burners for volatilization to test against cotton insects. The feeding system consists of a small tank mounted on the flame cultivator, to which is attached a small cylinder with four valves, which are connected with rubber hose lines that terminate in copper tubing fastened to the distal end of the burners. By manipulating the valves it is possible to feed insecticides at any desired rate. The insecticides do not interfere with the burners, and the device requires no special attention.

### FUMIGATION METHODS AND SCHEDULES

The study of factors governing tolerance of nursery plants to methyl bromide fumigation was continued in connection with treatments for products regulated under the white-fringed beetle quarantine. It was found that injury from this fumigant was associated with the transpiration rate (water loss) of the plants during the first 6 hours following treatment. A low rate of water loss was associated with a high degree of injury, and a high rate with little or no injury. By regulating the factors governing transpiration, the hazard of injury to plants was reduced. This information has been put to practical use in the treatment of plants. New schedules for soil fumigation at various temperature levels replace the previous single schedule for straight methyl bromide, and an entirely new series of schedules was prepared for the use of this fumigant in an organic solvent, which simplifies the equipment and handling procedure. The provisional schedule for the fumigation of commodities that might carry white-fringed beetle eggs, such as hay and peanuts, was replaced by a graduated series of schedules for various temperature levels.

Cooperative studies with the Delaware Agricultural Experiment Station on the tolerance of apple varieties to methyl bromide fumigation were terminated with the second season's tests.

The studies relative to treatments for commodities regulated by the gypsy moth quarantine were continued to perfect the fumigation of Christmas trees and greens, and forest and quarry products.

A new project to develop treatments for bulk cottonseed and other products regulated by the pink bollworm quarantine was begun early in the fiscal year. At the end of the year it had been determined that fumigation with methyl bromide, applied as a gas or injected as a liquid into the load either undiluted or in an organic solvent,

would kill larvae embedded in seeds located in all portions of the load, at dosages that did not reduce the germinating quality of the seed. Tests are under way to determine whether any effect on cottonseed cake or oil is evident.

Continued work on hydrocyanic acid fumigation of the California red scale on citrus confirmed previous conclusions that the gastight tent requires only about one-third as much fumigant to achieve effective control as does the standard duck tent. Tent material of firm weave, such as duck or sateen, appeared to be superior to material of open weave, such as twill or drilling. The blower applicator developed by this Bureau is somewhat more efficient than the usual commercial equipment, both in causing immediate scale mortality and in preventing subsequent population build-up. The design of the blower applicator has been modified to facilitate handling in the field. Equipment has been devised to remove residual gas from the tents at the end of the fumigation to eliminate hazard to the operators. An experimental evacuator which exhausts the gas upward removed most of the hydrocyanic acid in less than 50 seconds in a few tests.

### OTHER DEVICES AND METHODS

Investigations have indicated that the effectiveness of some insecticides against certain pests is increased when they are applied to the under surface of the leaves rather than to the upper surface. To test this method of application to cotton leaves, workers at the Stoneville, Miss., laboratory converted an eight-row power duster into a five-row duster which produced a strong blast. A set of long delivery pipes was utilized. By reversing the heads of the boom stanchions to lower the pipe supports to within a foot of the ground, the spreader nozzles could be directed upward.

A compact device for spraying insecticides for the control of flying insects in the home has been developed in which the space inside the compression cylinder is utilized to hold the liquid. Sprayers, or atomizers, as small as $\frac{7}{8}$ inch in diameter and $4\frac{1}{2}$ inches long have been made which contain sufficient highly concentrated spray to treat the average house several times.

### FOREST-MANAGEMENT PRACTICES HELP REDUCE LOSSES DUE TO INSECTS

Discovery of the spruce budworm in considerable numbers in the Adirondack section of northern New York in June 1945 made it necessary to transfer field studies from Ontario and Quebec, which were conducted in cooperation with the Dominion and Provincial Governments, to New York and the other Northeastern States. Sample plots have been established for studying the relationship of site, exposure, elevation, age and vigor of stand, density of stocking, stand composition, previous logging operations, and fires to the amount of damage resulting from the budworm outbreak. It is expected that this study, undertaken in cooperation with the United States Forest Service and the States of New York, New Hampshire, Vermont, and Maine, will lead to the development of management practices whereby the forest owner can maintain his spruce-fir stands in such a condition as to minimize injury by the spruce budworm. Observations in 1945

indicated that trees bearing a large crop of staminate flowers are most favorable for the development of the budworm larvae. Cultural and cutting practices that will reduce the number of such trees in a stand should aid in preventing budworm outbreaks.

The importance of the mountain pine beetle as an enemy of western white pine has necessitated a reevaluation of forest-management practices on public lands in northern Idaho and western Montana. The former policy of clear cutting the pine, leaving only a few seed trees, has been abandoned in favor of partial or selective cutting, about half of the total volume being removed by the initial cut. Much of the pine is overmature and suffering from competition with hemlock, fir, and larch for space, moisture, and nutrients. The problem appears to be one of reducing the density of the stands and thus improving growing conditions. Such cutting practices are being tested and if practical will enable the operators to cover the remaining stands of white pine more rapidly and remove a large quantity of valuable timber that would otherwise die and be wasted. At the same time they will leave a reserve stand of thrifty, growing trees which will be available for cutting at a later time, and thus contribute to sustained-yield management.

Control of the western pine beetle through the selective logging of high-risk trees showed encouraging progress during the year. Under the present active demand for lumber products, timber operators are able to carry on sanitation-salvage control at a substantial profit where high-hazard pine stands are accessible to sawmills. This method of indirect control, which is still in process of development, is rapidly gaining favor in the western pine areas, and is replacing the more wasteful methods of direct control by cutting and burning infested trees.

Records from Blacks Mountain Experimental Forest in California show that 6 years after sanitation-salvage logging was begun losses were still 83 percent less on treated areas than on untreated areas. One new operation covering 4,000 acres was undertaken during the year by a commercial company in the Burney area and over 3,000,000 board feet of high-risk timber were removed. On many other logging operations high-risk trees have been marked for cutting as a definite part of the marking policy. Studies of pine areas to determine the degree of risk from bark beetle infestations, as indicated by the number of susceptible trees and other factors in the stand, are of value in laying the ground work for sanitation-salvage control. Although no large program of hazard surveys could be undertaken during the year, a special study was made of 220,000 acres in eastern Oregon as the basis for future logging developments.

Following the spectacular outbreaks of *Ips confusus* (Lec.) near logging operations in California during 1944 and 1945, studies were started to determine the extent to which untreated slash contributes to the multiplication of the bark beetles and their subsequent attacks in green timber. Methods of treating slash and timing the cutting to prevent the breeding up of *Ips* populations have been tested. One of the more promising slash treatments was found to be spraying with 5 percent of DDT in kerosene. Where this treatment was used on green slash there was practically no attack by *Ips*, and where the slash

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had already become infested it gave 100 percent control of the larvae and over 90 percent control of the pupae and recently emerged adults.

## BIOLOGICAL CONTROL CONTINUES TO RECEIVE ATTENTION

### PARASITES IMPORTED FROM SOUTH AMERICA

The importations of natural enemies of insect pests during the year consisted of parasites of the cotton boll weevil, the vegetable weevil, and armyworms.

Shipments of boll weevil parasites from Peru consisted of 15 consignments containing 13,861 adults of *Triaspis vestiticida* Vier. and 234 adults of *Microbracon vestiticida* Vier. These parasites were forwarded for release in infested cotton fields in Texas and adjoining States.

Vegetable weevil parasites imported from Argentina and Uruguay comprised 4,702 cocoons of *Porizon parkeri* Blanch. and *P. argentinensis* Blanch. An undetermined nematode was found to parasitize up to 78 percent of the larvae in some sections of Argentina, and 885 parasitized larvae, each containing from 1 to 15 nematodes, were sent to the United States. All this material was forwarded to the Citrus Experimental Station of the University of California for rearing and colonization.

Armyworm parasites shipped to the Florida Agricultural Experiment Station consisted of 7,008 cocoons of *Apanteles* sp. and 100 cocoons of *Enicospilus merdarius* (Grav.) from Uruguay and 1,825 adults of a coleopterous predator, *Calosoma argentinense* Csiki, from Argentina.

Shipments of parasites of the sugarcane borer to the Puerto Rico Agricultural Experiment Station comprised 2,834 puparia of *Paratheresia diatraeae* (Brethes) and small numbers of *Parthenoleskia parkeri* Towns., *Apanteles* sp., and *Ipobracon* sp.

The importation from Australia of insect enemies of the Klamath weed was continued. Four shipments comprised 25,000 adults and 2,000 larvae and pupae of *Chrysolina gemellata* Rossi and 8,000 adults of *C. hyperici* Foerst., both of which are leaf feeders, and 1,473 larvae of *Agrilus hyperici* Creutz, which is a root borer. All this material was received through the courtesy of the Australian Council for Scientific and Industrial Research. Methods were developed for breaking the diapause of both species of *Chrysolina*, and feeding tests on cotton, tobacco, sweetpotato, flax, hemp, and sugar beet were completed. No feeding or reproduction occurred on any of these plants. The first field releases of *C. hyperici* were made in northern California early in 1945, and extensive releases of both species, totaling 19,000 adults, were made late in the summer of that year and in the spring of 1946. Eggs and larvae of both species have been recovered in some numbers at several release points. This work was conducted in cooperation with the California Agricultural Experiment Station.

### INTRODUCED PARASITE FAILS TO CONTROL CITRUS BLACKFLY IN MEXICO

An extensive survey of the principal lime-growing district of the State of Colima, Mexico, disclosed that the parasite *Eretmocerus serius* Silv., which was introduced in 1943, has not effected the control of the citrus blackfly.

### INTRODUCTION OF PARASITES OF EUROPEAN CORN BORER AND SUGARCANE BORER SUCCESSFUL

The colonization of about 233,000 parasites of the European corn borer in the United States in 1945, comprising 5 ~~domestic~~ species collected in cooperation with State agencies and 1 species received through the courtesy of the Canadian Science Service, brings the total number of exotic parasites released in this country against the corn borer to almost 7,000,000. Included among these parasites are species attacking the eggs, larvae, and pupae. All are occurring in considerable abundance in various locations in the infested areas, particularly in the Eastern States, most of them having been established following current releases in the more recently infested portions of the Corn Belt.

Parasitization of the sugarcane borer by two species of imported parasites resulted in low borer infestations in sugarcane in the Fellsmere, Fla., area.

### MACROCENTRUS ANCYLIVORUS REARED FOR USE AGAINST ORIENTAL FRUIT MOTH

Propagation of the oriental fruit moth parasite *Macrocentrus ancylivorus* Roh. on the potato tuber moth continued to be highly successful through 1945, yielding 8.2 females for each female used as breeding stock, and averaging 176 parasites for each pound of potatoes. The breeding rate fell below expectations in the spring of 1946, owing to adverse weather conditions. Shipments of parasites were sent to State agencies in Connecticut, New Jersey, South Carolina, Mississippi, and Ohio for liberation in infested orchards. Breeding stocks of the potato tuber moth and *M. ancylivorus* were sent to Connecticut, New Jersey, and Georgia.

### PARASITES PERSIST DESPITE DECLINE OF COMSTOCK MEALYBUG POPULATIONS

In 1945 infestations of the Comstock mealybug in northern Virginia were the lowest yet recorded, and several old ones in southwestern Virginia declined. The insect remained scarce in Ohio and New Jersey, but was moderately abundant in certain orchards in Delaware and Connecticut. Parasitization increased steadily during the summer of 1945 despite the decline in mealybug populations. *Allotropa burrelli* Mues. was the dominant parasite in Virginia, but *Pseudaphycus* sp. was most abundant elsewhere. Both species continued to show exceptional ability to persist as mealybugs became scarce, and to extend their distribution naturally. Both were found to adapt themselves rapidly to a wide range of orchard conditions and appeared to be of nearly equal value as control agents. The work of colonizing the parasites of the Comstock mealybug in apple orchards wherever new infestations appeared was continued in cooperation with State agencies.

### WORK WITH MILKY DISEASE OF JAPANESE BEETLE CONTINUED

The program for distributing the milky disease of Japanese beetle grubs was continued in cooperation with State agencies in nine States and with the Army Service Forces in the First, Second, and Third Service Commands. In 1945, 6,863 acres were treated in cooperation with State agencies, and 559 acres at seven military reservations.

Spores of the milky disease organism, stored in dried-blood smears on glass slides, have now remained alive and effective for 10 years. The standard spore dust has lost little or none of its infectiousness after storage for 6½ years.

### PARASITES OF COTTON BOLL WEEVIL STUDIED

Investigations at Tallulah, La., showed that the parasites *Triaspis vestiticida* and *Microbracon vestiticida* imported from Peru during the last several years and released in cotton fields in Texas and Louisiana would oviposit on boll weevil larvae in squares and develop and emerge as adults. Both of these parasites have been reared from cotton squares collected in the fields after the parasites had been released. However, no evidence has as yet been obtained to indicate that these parasites have in any case survived a winter in this country. Incidental studies have shown that the native parasites are active each year in all States where the boll weevil has been studied.

### SPRUCE BUDWORM PARASTES INVESTIGATED

The spruce budworm infestations covering several hundred thousand acres in Colorado suddenly decreased during the past year. A study of the entomophagous parasites showed a very high population of a number of species. Conclusions regarding the total contribution of parasites to the decline cannot be drawn until other control factors are studied. Three species of parasites that do not occur in the Northeastern States were found in Colorado, one of them, *Ceromasia auricaudata* T. T., in very large numbers. During June 1946 approximately 60,000 spruce budworm larvae were collected in Colorado for rearing of these three species for shipment and colonization in the East. Studies of biological control of the budworm in the Northeast were undertaken in the spring of 1946 and will be correlated with work in Colorado and Canada.

### PROGRESS MADE IN DEVELOPMENT OF INSECT-RESISTANT PLANTS

Further advancement toward commercial release was made, in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and interested State agencies, in the breeding of many lines of hard and soft red winter wheats with high resistance to the hessian fly, including probable release by Indiana in 1948 of a variety which derives its resistance from Illinois No. 1–W38. The fly-resistant Poso 42 and Big Club 43 varieties are being grown commercially in California and continue to be satisfactory. The highest type of resistance to fly in hybrid wheats occurred in derivatives of P. I. 94587 under intensive fly attack in the greenhouse. In 1945 and 1946 extensive plantings of the semiresistant variety Pawnee, developed by the Kansas Agricultural Experiment Station in cooperation with the Department, have been comparatively free from infestation in central Kansas, where standard varieties were moderately to severely infested. Several barley varieties subjected to severe hessian fly infestation in greenhouse tests were distinctly resistant to this fly.

Sugarcane variety C. P. 34/79, which has shown high resistance to the sugarcane borer in Louisiana and Florida, has been released by the plant breeders for commercial use in Florida.

Tests conducted in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and interested State agencies have shown that certain lines of corn are comparatively unattractive throughout their growth to egg-laying European corn borer moths, that the dent corn inbred line P8 is outstanding for tolerance to corn borer infestations, and that a number of additional dent, sweet, and popcorn lines apparently possess considerable resistance to the borer.

Resistant inbred lines, in single crosses with susceptible lines, greatly decrease corn earworm damage, but additional resistant lines are necessary in three-way or double crosses to provide high protection from this insect. High resistance to the earworm is being shown by selections of the flour corn line No. 221. Among southern corn hybrids, Louisiana 1030 appears particularly promising as a source of earworm resistance. Certain Evergreen sweet corn inbreds apparently have some resistance to both the earworm and the European corn borer.

Additional strains of alfalfa resistant to the pea aphid have been identified, for possible use in the alfalfa-improvement program being conducted by Department and State agronomists.

Progress in developing aphid-resistant strains of cotton is being made at the Stoneville, Miss., laboratory in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the State Agricultural Experiment Station. It has been discovered that aphid resistance is coupled with glabrous leaves. The location of hairs on the leaf is apparently more important than average pilosity of leaf. The strains with the greatest number of hairs on the veinlets are more susceptible to aphids because they afford the insect more physical protection from adverse weather conditions. In some strains of cotton, stellate groups of hairs predominate; that is, usually five to nine hairs radiate from a central axis. Other strains may have single hairs, or two to four hairs spaced more uniformly over the area. Groups of hairs so arranged afford more protection to the aphids than a like number of stellate hairs. About 3,500 plants of the crosses are being studied this year.

### STUDIES INDICATE TIME OF YEAR PEACH MOSAIC SPREADS

In tests conducted at Mesa, Ariz., single cases of peach mosaic resulted in 1945 and again in 1946, when healthy potted peach trees were placed on scaffolds in the canopies of diseased peach trees during the late-dormant to the petal-fall stage of development, and exposed to the insects normally present in the orchard. Trees exposed later in the 1945 season did not become infected. These observations indicate the best period of the year for conducting experiments to determine what insect is responsible for the spread of peach mosaic. This work was done in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

### DEVELOPMENTS IN THE FIELD OF BEE CULTURE

#### TOXICITY OF ANTIBIOTIC EXTRACT REDUCED

Satisfactory progress has been made in the study of the antibiotic associated with spores of *Bacillus larvae*, the causative organism of American foulbrood, which has been found effective in laboratory cultures against various organisms, including those causing boils, malta fever, undulant fever, and human and bovine tuberculosis.

The first preparations of this antibiotic, however, were exceedingly toxic to test animals. An aqueous extract, as originally prepared, killed mice when given in doses of 10,000 standardized units, and even 1,250 units made them ill. A method has been developed for removing or destroying the toxic compounds associated with the antibiotic, so that mice given a dosage of 5,000 units of the purified product show only a slight bulging of the eyes for about 20 to 30 minutes and rapid breathing, and in many cases even the bulging of the eyes is absent. Preliminary experiments indicate that the antibiotic is more stable to heat when purified and in dry form than when unpurified.

### ASPARAGUS PROMOTES SPORULATION OF BACILLUS LARVAE

Present culture media do not promote the growth and sporulation of *Bacillus larvae* in the laboratory sufficiently to provide the antibiotic in amounts needed for experimental work. Consequently, spores occurring in the dried-down remains, or "scales," of larvae dead from American foulbrood must be depended upon as the source of supply. It is necessary to pull the scales out of the cells of the brood comb by hand, and this is a tedious, painstaking job. Attempts to develop suitable culture media are therefore in progress. Among the year's results, a thermostable factor needed for the growth and sporulation of *B. larvae* has been found in aqueous extracts of sealed honeybee larvae. Furthermore, a satisfactory substitute for this factor has been found in strained asparagus pulp. Although the growth factor has been purified considerably by fractionation, the compound or compounds responsible for its activity have not yet been isolated in pure form.

### MILK TEST FOR AMERICAN FOULBROOD SIMPLIFIED

The milk test for American foulbrood, based on the production by *Bacillus larvae* of an enzyme that hydrolyzes milk, has been further simplified so that it can be used in the field. The only equipment required is a small vial, water, and a few drops of whole milk or a little skim milk powder. The cost of powdered milk for 100 tests does not exceed 1 cent. The test should result in better control of this disease, since it enables inspectors to make definite on-the-spot determinations without the delay occasioned when samples are sent to Washington for a laboratory diagnosis.

### AMERICAN FOULBROOD SPORES RETARDED BY SULFATHIAZOLE AND PENICILLIN

Sulfathiazole, in concentrations of 25 mg. per 100 grams in laboratory cultures, has been found to retard spore germination and resulting vegetative growth of *Bacillus larvae*, but not completely to inhibit such germination and growth. On the other hand, some apiary experiments in which 15 mg. of sulfathiazole in 100 grams of sugar sirup was given to infected colonies placed on dry combs, and to infected colonies left on their original combs except that their brood combs were replaced with dry combs, indicate the possibility of a cure. The tentative conclusion is that sulfathiazole, when fed to colonies, may slow down spore germination in larvae of susceptible age until they are beyond the age where infection can take place.

Penicillin in amounts down to 1,000 units prevented spore germination of *Bacillus larvae*, and in amounts down to 100 units inhibited spore germination and subsequent vegetative growth, while as little as 50 units completely prevented growth of vegetative-culture transfers.

### NOSEMA WIDELY DISTRIBUTED

A survey indicated that Nosema disease may be as widely distributed in the South as in the North. Of 168 samples of bees taken from 8 package- and queen-rearing apiaries in Mississippi, Louisiana, and Alabama, 60 percent contained infected bees.

A temperature of 85° F. was found to be highly favorable to the development of Nosema in inoculated bees. The maximum number of the parasites at this temperature occurred 14 to 16 days after the inoculation. Preliminary work indicates that Nosema may be checked but not destroyed by keeping bees at temperatures of 95° F. and above.

Sulfadiazine and sulfathiazole were ineffective against Nosema.

### BEE POISONING BY DDT AND OTHER INSECTICIDES INVESTIGATED

DDT when properly applied appears not to have lasting effect on honeybee colonies in or near fields treated with this insecticide. This is quite in contrast to arsenicals, the use of which causes serious injury to bees and other pollinating insects. This conclusion has been reached after extensive observations in Texas on 500 acres of cotton dusted nine times with 10-percent DDT at the rate of 15 pounds per acre and observations on four colonies near 150 acres of cotton sprayed four times by airplane with DDT in xylene at dosages equivalent to 15 or 30 pounds per acre of 10-percent DDT. Furthermore, the entrance of one hive was dusted heavily with DDT three times without discernible injury to the colony. Colonies in large orange groves in California that were heavily dusted with DDT likewise showed no serious injury. When alfalfa was treated with DDT, the bees stayed away for 2 or 3 days and then returned and worked the blossoms vigorously as though no insecticide had been applied. However, when alfalfa is dusted while in full bloom many field bees have been killed.

More than 900 samples of bees, pollen, and plant blossoms were received from State authorities in Utah for arsenic determination. A lower average arsenic content was found in the samples in 1945 than in the previous year. Relatively high arsenic content was found only in the neighborhood of smelters, and bee losses were insignificant except in those areas. The smelters reduced their activity somewhat during the year.

A survey in Arizona showed that losses of bees caused by vegetable dusting were as high as those caused by cotton dusting. An incomplete estimate showed the losses to be at least 7,000 colonies, with indications that the final figure would be twice that number.

Benzene hexachloride proved exceedingly toxic to bees under laboratory conditions.

### ARTIFICIALLY INSEMINATED QUEENS RIVAL NATURALLY MATED QUEENS

Research on the artificial insemination of queen bees was discontinued this year, because the Bureau has developed the technique for

it to such a degree that artificially inseminated queens are now being produced that prove just as good in tests on honey production, disease resistance, and other factors as do naturally mated queens.

Eighty queens were artificially inseminated for use in productivity tests, as compared with 36 in 1944. In addition 73 queens were naturally mated in an isolated location for use in these tests, as compared with 54 in 1944. Sixty-eight queens were artificially mated for studies on American foulbrood resistance. The artificial matings involved the inbreeding of three lines and making two- and three-way crosses of these lines. These crosses compared favorably as to productivity with the best commercial strains that have yet been tested, suggesting that hybrids with even better performance than known commercial strains may be developed. They showed no higher resistance to American foulbrood than did the inbred lines, however. Some of the three-way hybrids were very vicious.

Of two strains inbred for resistance to American foulbrood, whose colonies headed by artificially mated queens had shown 100-percent resistance in 1944, one strain, known as W64, still showed 100-percent resistance during 1945 in tests involving 13 artificially inseminated queens, while the other, known as W39, showed 75-percent resistance in tests with 12 artificially inseminated queens. The three colonies of the latter group that did not recover were destroyed toward the end of the season because of viciousness before they had a complete chance to recover. An average resistance of 86 percent was obtained from a group of seven naturally mated queens of strain W64 inbred for seven generations, and an average resistance of 76 percent from a similar group of queens of strain W39 inbred for eight generations. Seventeen colonies of a new inbred strain, A18, headed by artificially inseminated queens, showed 94-percent resistance. Twelve colonies headed by artificially mated queens, representing a triple cross of the three strains, showed a resistance of 75 percent.

Two hundred and thirty-six naturally mated queens of resistant stock were reared and sent to cooperating agencies.

### POLLEN SUPPLEMENTS FURTHER TESTED

Cakes of pollen supplemented with soybean flour proved superior in brood-rearing value and attractiveness to bees over cakes of soybean flour alone or fortified with dried brewers' yeast. The palatability of the fortified soybean cakes was improved by the addition of 5 percent of dried egg yolk.

Colonies overwintered in the North, which were fed on soybean-pollen supplement from February 20 to the middle of April, reared on an average 10 pounds of bees. After removal of 2¼ pounds of package bees per colony, sufficient populations were left to build into good producing colonies.

### POLLINATION EXPERIMENTS AND OBSERVATIONS

Preliminary studies were made on the effect of directional feeding to induce bees to increase their pollen-gathering activity in alfalfa fields. Plain sugar sirup, sirup to which alfalfa pollen had been added, and sirup containing macerated alfalfa blossoms were sprayed at sundown on bees inside the hives of test colonies. The pollen trapped

from these colonies indicated that the sirup containing alfalfa pollen stimulated the bees to gather alfalfa pollen. In another test, observations on bees moved from a locality where they were gathering only alfalfa pollen to one which had other plants to compete with alfalfa, failed to indicate that the bees gathered pollen from the alfalfa found in their new location.

Pear pollen trapped from a bee colony was tested for its effectiveness in pollination by mixing it with sugar sirup and then spraying on emasculated pear blossoms under tents. Practically no fruit was set. The pollen also showed little power of germination when tested in the laboratory on agar plants or in sirup. Bees from a colony moved into a pear block collected 70 percent of their pollen from the pear trees for the first 3 or 4 days and then moved out of the orchard and gathered pollen chiefly from French prune. The colony had been moved 4 miles so that a complete reorientation by its bees was necessary.

In certain localities carrot blossoms proved to be important competitors of alfalfa blossoms for the visits of bees.

## SURVEYS PROVIDE BASIC KNOWLEDGE FOR INSECT CONTROL

### ACTIVITIES OF THE INSECT PEST SURVEY

The Insect Pest Survey prepares and distributes to State and Federal workers, insecticide manufacturers and distributors, and others concerned with insect control summaries of current information on the occurrence, distribution, and abundance of insect pests throughout the United States. During the year seven monthly statements and one annual statement were issued, as well as seven special supplements to the Insect Pest Survey bulletin. Approximately 3,500 reports received from State collaborators and Bureau personnel served as the basis for preparation of the summary statements. These reports, together with about 15,000 obtained in connection with a special survey conducted by the Bureau in recent years around ports, were added to the permanent files of the Insect Pest Survey. These added records represent 200 genera and 700 species of insects not previously on file as occurring in this country.

### EMERGENCY SURVEYS OF COTTON, VEGETABLE, AND FRUIT INSECTS

The emergency survey to obtain information on the seasonal abundance, distribution, and damage caused by the boll weevil, cotton leafworm, bollworm, cotton flea hopper, cotton aphid, and other important pests of cotton, and on the availability of insecticides for their control, was continued during the summers of 1945 and 1946. This survey is made in cooperation with Federal, State, and private agencies, but in most of the States the major part of the work is done by this Bureau. During the season of 1945, 19 weekly reports on cotton-insect conditions in the various States were issued. These reports are of value in bringing about the orderly distribution of insecticides and in furnishing information to farmers, county agents, extension entomologists, and others interested in the cotton industry. The reports are based on records of insect abundance made in thousands of fields in Arkansas, Georgia, Louisiana, Mississippi, North and South Caro-

lina, and Texas, and in some fields in Alabama, Arizona, California, Florida, Illinois, Kentucky, Missouri, New Mexico, Tennessee, and Virgina.

The special emergency survey of insects that attack vegetables and truck crops and requirements for their control was continued throughout the year in cooperation with State workers, industry, and other agencies. A statement was issued each week summarizing the information relative to the insect infestations and the insecticide and equipment situation. A similar emergency survey of fruit insects controlled by nicotine was started in April 1946, because of the critical nicotine supply situation. The purpose of both surveys was to help insure the distribution of insecticides to localities or districts where they were most urgently needed.

### OUTBREAKS OF FOREST INSECTS

The outbreak of the Englemann spruce beetle in Colorado continued to be one of the most destructive insect outbreaks in timber. More than a billion board feet of Englemann spruce were killed in 1945, bringing the total loss of timber during the last 4 years to more than 3 billion board feet. The heaviest loss has occurred on the White River National Forest, where nearly 2.5 billion board feet, or 84 percent of the stand, have been killed. In 1945 severe infestations were found on the San Juan and Montezuma National Forests, bringing the total number of national forests in western Colorado severely infested to seven. All these infestations can equal in severity the outbreak on the White River Forest and also spread to other national forests. The current rate of timber loss is four to six times the estimated total annual growth on all forest lands of Colorado. The severe but localized outbreak on the Dixie National Forest and the Cedar Breaks National Monument in southern Utah was successfully controlled by the agencies concerned. The very heavy feeding of woodpeckers upon the insect brood aided materially in the success of this control work. Although the woodpeckers have become very abundant in western Colorado, most of the beetle infestations have reached such magnitude that their success in reducing the outbreaks there is improbable. Even though no artificial control work is feasible in the extensive infestations that now exist, the surveys should be continued and enlarged so as to locate incipient infestations in adjacent areas while they are yet controllable.

In Utah local outbreaks of the Black Hills beetle occurred in four areas, in which a total of approximately 7,000 trees were cut and treated by the agencies concerned. An uncontrolled outbreak on the Wasatch National Forest increased in extent from 13,900 infested trees in 1944 to 33,900 trees in 1945.

A very severe and extensive outbreak of the mountain pine beetle has been reported from the general region of the Caribou, Targhee, and Teton National Forests and the Grand Teton National Park in Idaho and Wyoming. No adequate examination of this outbreak has been made, but it may prove to be similar to the tremendous outbreak in the Beaverhead and Bitterroot areas in Montana about 15 years ago. Detection surveys during the fall of 1945 revealed a very spotty distribution of bark beetle infestations in the pine stands of the Pacific

Coast States. For the greater part of the western-pine region the low endemic infestations of recent years still prevailed, but in certain areas there were sudden increases of *Ips* and *Dendroctonus*. One area that was hard hit was the Cobb Mountain resort district about 100 miles north of San Francisco, which is used for recreation by thousands of people in central California. Late in the fall of 1945 an outbreak of *Ips confusus*, supplemented by the western pine beetle, developed in the ponderosa pine stands which compose the principal forest cover in the resort areas. A total of 1,600 trees were killed in small to large groups. This timbered area is privately owned and outside the jurisdiction of Federal land-managing agencies. However, the State of California acted promptly by declaring the area a zone of infestation and started eradication measures in cooperation with the owners.

### PESTS OF MAN AND ANIMALS

Much additional information on the mosquito species and their distribution in Oregon, Washington, and Idaho was obtained by operating New Jersey light traps in different ecological environments in the Pacific Northwest. These data were supplemented by a large number of hand collections of larvae and adults.

The screwworm survey was continued, and infestations were reported from western Florida, southern Alabama, and the southern third of Georgia. Two cases were found in sheep unloaded in Mississippi which had been shipped from central Texas. They were promptly treated with smear 62, and no further cases were reported from Mississippi. This survey has served well to determine the needs of critical ingredients for this smear and to acquaint the livestock industry with the superiority of this remedy for the control of screwworms. With the cooperation of State personnel, particularly the entomologists and county agents, smear 62 has been introduced in all the affected States, and livestock owners have saved many valuable animals and prevented many local outbreaks and further spread of this pest.

The short-nosed cattle louse was found in Florida for the first time in the fall of 1945. In Florida this louse is commonly called the tail louse of cattle, for it confines its activity to the switch or brush of the tail. It is difficult to eradicate.

### ORIENTAL FRUIT MOTH SURVEY CONTINUED IN WESTERN STATES

Prior to 1943, the oriental fruit moth was known to occur as far west as Texas, Oklahoma, and Kansas, and there was also a known center of infestation in California. The survey of 1943 disclosed it in Iowa and Nebraska. In 1944 cooperative Federal-State surveys revealed slight occurrences of this fruit moth in Colorado, Utah, and Idaho. In view of uncertainty in several Western States as to what attitude to adopt toward the situation, the survey was continued in 1945, covering the three States found slightly infested in 1944 and as well other Western States exclusive of California and Wyoming. As in previous years, the survey methods included the use of baited traps to catch adult moths and twig inspections for recovering larvae. Con-

firmation of 1944 findings was obtained by picking up oriental fruit moths in three counties in Colorado, three in Idaho, and one more in Weber County, Utah. The 1945 survey also disclosed their presence in Malheur County, Oreg., and in four counties in Washington. It was not found in Arizona, Nevada, Montana, or New Mexico.

### GOLDEN NEMATODE FOUND TO OCCUR OVER A SLIGHTLY LARGER AREA

The golden nematode survey program, carried out cooperatively with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the New York State Department of Agriculture and Markets, aimed to determine more definitely the distribution of this parasite in Long Island, particularly in the environs of the known infested area. Surveys made July 1 to September 1, 1945, covered 365 farms, in which 8,700 acres out of their 12,019 acres of potatoes were examined by the root-inspection method. Five new infestations were thus discovered, all close to the known infested area. In 1946 a survey by the soil-wash method was devised, and at the end of June this procedure had disclosed five more infested fields in over 3,000 acres surveyed, all adjacent to known infested land.

### INSECT IDENTIFICATION A BASIC SERVICE

Identifications were made of 51,797 samples of insects received from the following sources: (1) The various divisions of this Bureau engaged in research, control, quarantine, and survey activities; (2) the Army, Navy, Public Health Service, and other Federal agencies; (3) agricultural colleges and experiment stations of every State; (4) individuals, private institutions, and pest-control operators; and (5) foreign governmental agencies and institutions concerned with insect control.

Research in insect classification, essential for the improvement and expansion of the identification service, resulted in the preparation and submission for publication of 27 technical manuscripts covering specific problems in all the major orders of insects.

### PUBLIC INFORMED OF BUREAU ACTIVITIES

In order to give due publicity to changes and additions to plant-quarantine regulations as required by law, numerous service and regulatory announcements, BEPQ circulars, and miscellaneous regulatory publications were prepared and published during the year. Approximately 100,000 copies of such publications were distributed. Results of the Bureau's research and recommendations based thereon were made available to the public in 59 manuscripts approved for publication in the printed or processed series of the Department or Bureau and 310 approved for publication elsewhere. Information of a popular or semipopular nature approved for release included 100 press and 57 radio items, 14 feature articles, and 6 articles for various yearbooks. Approximately 680,000 printed publications on entomological subjects, beside those of a regulatory nature, were distributed. In addition many thousands of copies of processed publications were distributed, largely in response to the demand for information on DDT, most of which was not yet sufficiently complete for publication in printed form.

## CONTROL PROJECTS

### SUPPRESSIVE MEASURES APPLIED AGAINST JAPANESE BEETLE

More widespread than in any previous year, the 1945 Japanese beetle trap scouting program conducted in cooperation with State agencies extended to 698 localities in 35 States. This amounted to 236 more localities in twice as many States as in 1944. Some traps were operated in every State outside the known infested area except South Dakota. Most of them were set out east of the Mississippi River, with the heaviest concentration in sections adjacent to the regulated areas. The total number of traps used, however, was 56,377, about 10,000 fewer than during the previous year. Beetles were caught in 96 cities and towns, in 35 of them for the first time.

Cooperation of officials of the Army, Navy, and many municipalities was enlisted in a Nation-wide precautionary trapping program at airports. This program embraced all airports outside the infested area considered of major importance as possible destinations for accidental carriage of adult beetles by plane, extending to 107 airports in 28 States. Batteries of 24 traps each were operated along boundaries of the airports for approximately 6 weeks. Solitary beetles were caught in traps set at airports at New Orleans, La.; Savannah, Ga. (Hunter Field); and Chesapeake, Ohio (Huntington, W. Va.). Two beetles each were recovered at the Charlotte, N. C., and Memphis, Tenn., airports, and three beetles were trapped at the Charleston, S. C., municipal airport. Evidence in each case indicated that these specimens were hitch-hiking beetles transported to new environs by airplane movement.

By the end of the fiscal year trapping was under way in all nonquarantined States east of the Mississippi River except Wisconsin, as well as in scattered localities in Arizona, California, Idaho, Missouri, and Nebraska. Beetles had been trapped in Augusta, Austell, Atlanta, and Dahlonega, Ga.; in St. Louis, Mo.; in 12 North Carolina communities; and at Greenville and Greenville Army Air Base, S. C. Those collected at the Wilmington, N. C., airport comprised the only first record thus far for the 1946 season.

Lack of rainfall in the summer of 1944 resulted in a rather general reduction in beetles caught during 1945 at isolated infestations where combination trapping and soil-treating programs have been depended upon to keep the beetles in check. The same condition existed in the continuously infested area, where a marked drop in beetle population occurred, except in a few places where 1944 precipitation was near normal. During the fall of 1945 and spring of 1946 State-Federal cooperative soil treatments were applied to important isolated infestations covering 544.25 acres in Georgia, Illinois, Indiana, Michigan, Missouri, New York, North Carolina, Ohio, and Virginia. These again involved the application of lead arsenate at the rate of 500 pounds per acre within a radius of approximately 300 feet of significant beetle finds. A few of the infestations were so extensive that soil treating was not considered practicable, and quarantine action was taken.

Contrasted with the 708 beetles trapped in Chicago in 1944, this year's capture of 164 showed an improved situation there. Fewer beetles were trapped in Indianapolis, Ind., than in any year since

the first beetles were caught there in 1934. In St. Louis, Mo., the infestation was again at a minimum, with only 7 beetles caught.

### DDT APPLIED BY AIRCRAFT AND GROUND BLOWERS CONTROLS THE GYPSY MOTH

During the year DDT was applied by aircraft, a new type of blower apparatus, and knapsack sprayers on more than 125 square miles of territory infested with the gypsy moth in Pennsylvania, eastern New York, and western New England. Preliminary but intensive checking of results throughout the season indicates complete control in areas treated by blowers and aircraft, and from drastic reduction of the pest to complete control where knapsack sprayers were used. Final checks will be made during the fall and winter months of 1946–47. The significance of the use of DDT and the methods of application on future programs is strikingly illustrated by comparison with control conducted during past seasons with arsenate of lead applied by high-powered ground spray machines. A larger infested acreage was treated in 1946 than during the period 1937–42, when control operations were augmented through allotments from relief agencies such as CCC and WPA.

During the latter part of the year an additional $61,000 was made available from funds appropriated by the Congress in a deficiency bill. Contracts were awarded to five commercial aircraft spraying companies, and four axial-flow blowers were purchased, as well as several tons of DDT. The States of New York and Pennsylvania purchased the solvents and supplied additional labor and part of the DDT needed for the expanded program. Slightly in excess of 32 square miles of infested woodlands were treated by the contractors, and the equivalent of 28 square miles of residential properties, street trees, and margins of woodlands were treated by blowers. The practicability of treating extensive forest areas by aircraft and the blower type of apparatus was fully demonstrated.

Intense interest in these new methods was also shown by State pest-control agencies, commercial operators, and the general public in the heavily infested portions of New England, where control of gypsy moths is the responsibility of the States, towns, and other local agencies. The exact extent to which DDT was applied in this critical area is not known as of the close of the year. However, incomplete reports show that commercial operators applied DDT by blower equipment in approximately 50 towns, the extent of coverage ranging from one or more estates to all shade and roadside trees and woodland areas abutting on highways. Three operators are known to have applied DDT by aircraft for control of gypsy moths. Commercial companies also treated golf courses, summer hotels, race tracks, open-air pavilions, estates, and similar places for fly and mosquito control. Expansion of this type of work in the general infested area will afford protection to the suppressive area by reducing the hazard of natural spread of gypsy moths.

Nearly 15,000 traps baited with sex-attractant materials were used on more than 5,500,000 acres within and beyond the known limits of gypsy moth infestation. This work, which was done in cooperation with State agencies, resulted in detection of local spread of the pest from contiguous infestations along Lake Champlain in the vicinity

of Plattsburg, N. Y., as well as in the eastern portions of Montgomery, Fulton, Warren, and Essex Counties in New York State. One isolated infestation was located in Pennsylvania in Wayne County. All such areas were treated with DDT during the control season.

All control and survey work concerning the brown-tail moth was conducted by the New England States. Reports indicate that heavy infestations were present only in limited areas along the coast of New Hampshire and southern Maine.

### SWEETPOTATO WEEVIL ERADICATION EXTENDED

The Bureau cooperates with six States in the eradication of the sweetpotato weevil from commercial sweetpotato-producing areas and seed centers, by inspecting fields, seedbeds, and storage places, by checking fields for volunteer plants, and by supervising the cleaning or fumigation of storages and shipments.

In the fiscal year 1946 up to March 31, 29,776 inspections of fields, seedbeds, and storage houses were made in Alabama, Florida, Georgia, Louisiana, Mississippi, and Texas. Measures for weevil elimination on individual farms were successful to such an extent that 580 farms were released as having shown no weevils for a year. On the other hand, 1,110 new infestations were discovered, these representing limited extensions from known infestations, but primarily in areas to which the control work has been but recently extended. It is thought that seed movements from uncertified sources, arising from war-stimulated sweetpotato production, account for a substantial number of these new infestations, the most outstanding of which have been found in south-central Georgia and in an important seed-producing area of Louisiana. At the end of the year there existed 1,658 active infestations. Since 1937 a total of 5,561 properties have been freed from weevils.

### GRASSHOPPER CONTROL PROTECTS CROPS WORTH 30 MILLION

During the 1945 season grasshopper control was conducted in cooperation with State agencies in 23 Central, Midwestern, and Western States, and these operations afforded protection to 5,980,000 acres of crops worth more than $29,550,000. Over 25,000 farmers participated in the program, spreading 12,590 tons (dry weight) of bait furnished by the Federal Government. The Bureau financed the spreading of an additional 530 tons of bait on roadsides, irrigation canal banks, right-of-way, and idle lands; other Federal agencies spread 390 tons of bait on lands under their jurisdiction. An estimated 2,235,000 acres were baited in the combined operations.

The major control problem in the 1946 season was expected in northern Colorado, western Kansas, eastern Montana, western Nebraska, south-central and western South Dakota, central Texas, and eastern and north-central Wyoming, where infestations range from light to severe. Estimated needs for bait in 1946 slightly exceeded the amount used in 1945.

Weather during the early spring of 1946 was favorable to an early hatching and rapid development of grasshoppers. In May, however, unfavorable weather over the northern Great Plains retarded hatching and development. Infestations increased rapidly in June.

Favorable weather in Arizona, California, and Texas allowed farmers to begin control early, and operations were accelerated up to the close of the year. The total amount of bait mixed for grasshopper control in all States through June 30 was 4,225 tons (dry weight). This exceeded by 1,585 tons the amount reported mixed at the same time in 1945.

Specifications are now available for bait mixers of a size appropriate for counties or communities to build and maintain, and also for lightweight bait spreaders such as pictured (fig. 1). These spreaders give an even distribution of grasshopper or Mormon cricket bait over a swath 50 feet wide.

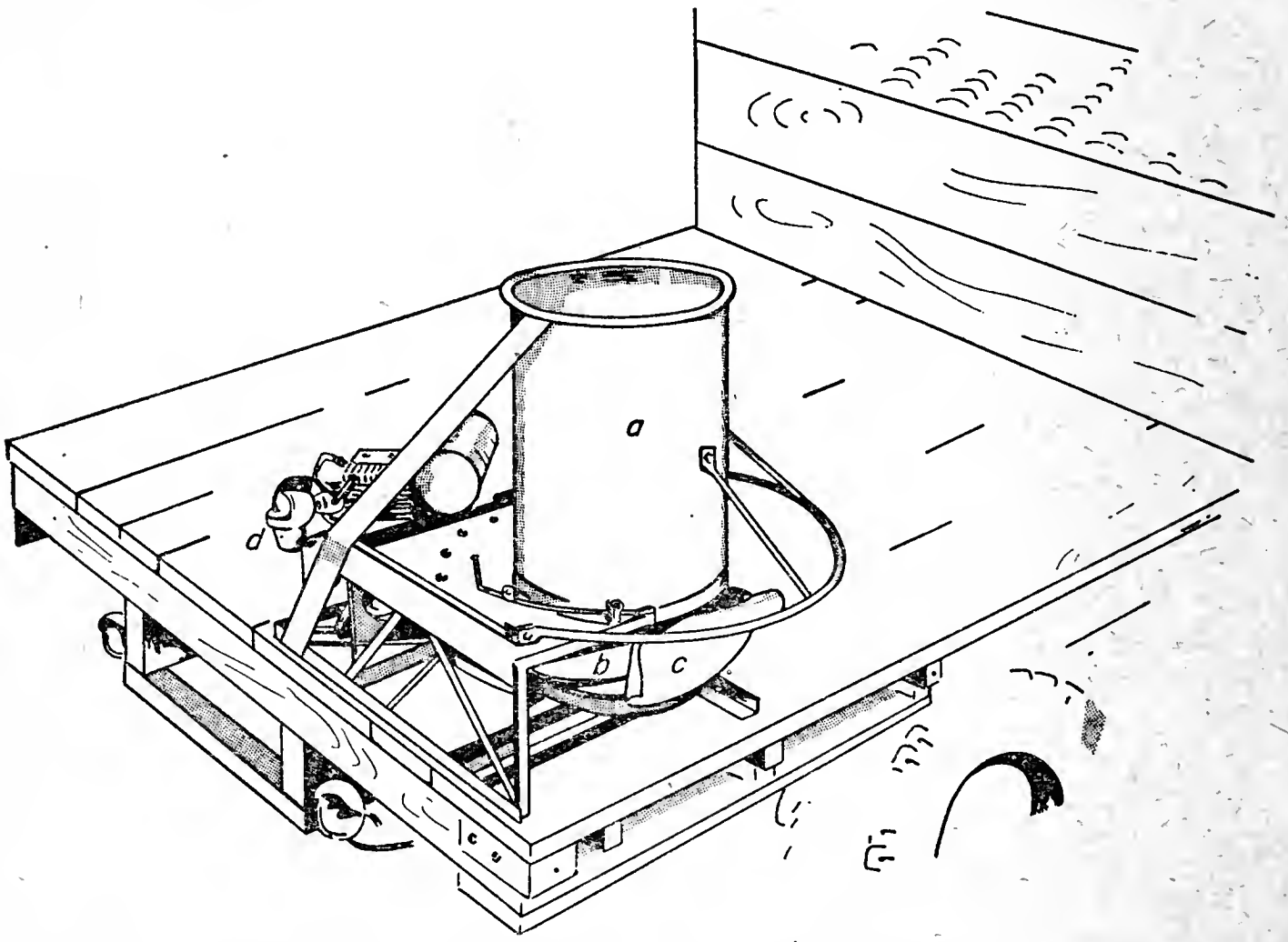


FIGURE 1.—Newly designed bait spreader consisting of hopper (*a*), horizontal disk (*b*) with especially designed blade (*c*), powered by 3- to 5-horsepower gasoline motor (*d*), which can be driven at 1,800 to 2,000 r. p. m.

### COOPERATIVE EFFORTS PROTECT AGAINST MORMON CRICKETS

During 1945 Mormon cricket control work was conducted in cooperation with the States of Idaho, Nevada, Oregon, Washington, and Wyoming. The Federal Government financed the spreading of approximately 1,540 tons (dry weight) of poisoned bait over about 158,000 acres of land. On about three-fifths of this area applications were made by airplanes and on two-fifths by power spreaders; some acreage (less than 1 percent) inaccessible to mechanical spreading equipment was baited by hand. These operations afforded valuable protection to range and adjacent crop lands.

Adult-population surveys made during the summer of 1945 indicated that the infestation in 1946 probably would be no more extensive than in the previous year. Large numbers of crickets developed during the spring of 1946 in several areas in Idaho, Nevada, Oregon,

and Washington, and this called for an increase in the amount of control work.

In 1946 federally financed control was undertaken in cooperation with the States of Idaho, Nevada, Oregon, and Washington. Control work was begun early in April in Nevada, Oregon, and Washington, and in mid-May in Idaho, and by the end of June, 1,120 tons (dry weight) of bait had been spread on 151,000 acres of land by airplanes, by power spreaders, and by hand. Airplane baiting, which was begun in Nevada early in May and in Idaho early in June, was responsible for 19 percent of this acreage.

### CHINCH BUGS CONTINUE AT LOW EBB

During the spring and early summer of 1945 cool weather, extremely heavy precipitation, and fungus disease reduced the potential chinch bug damage in most areas of the Central and Midwestern States. As a result farmers used only a small portion of the estimated barrier-material needs of 7,500,000 gallons of creosote oil or an equal number of pounds of dinitro-*o*-cresol dust. About 2,500 farmers in 8 States participated in the control program, and they used 47,000 gallons of creosote oil and 222,000 pounds of dinitro-*o*-cresol dust, furnished by the Federal Government, to construct and maintain 380,000 rods of barrier. County leaders estimated that 75,000 acres of crops, valued at approximately $1,200,000, were protected by these measures.

Government-owned barrier materials in Federal, State, and county storage in 1946 are sufficient to construct 2.5 million rods of barrier. These materials are adequate for control unless there is a general outbreak during the 1946 season, in which event additional quantities may be required. At the close of June chinch bugs had been reported in economic numbers only in a few isolated localities.

### ARMYWORMS AND ARMY CUTWORMS RECEIVED ATTENTION IN SOME STATES

Armyworms and army cutworms developed in 1945 to the extent that control measures were necessary in eight Central, Midwestern, and Western States. A total of 152 tons (dry weight) of standard-formula grasshopper bait were furnished farmers by the Federal Government. Ninety-seven percent of the bait spread was for armyworm control in Arkansas and Illinois and for army cutworm control in Montana. About 400 farmers participated in cutworm control, spreading bait on an estimated 30,000 acres of land.

During the spring of 1946 army cutworm infestations which required control developed in several Midwestern and Western States. Small quantities of bait were issued to farmers in Colorado, Montana, Nebraska, Oklahoma, South Dakota, and Wyoming. Outbreaks of armyworms were not reported.

### WHITE-FRINGED BEETLE NOW OCCURS IN GEORGIA

At the end of 1945 white-fringed beetle infestations in five States—Alabama, Florida, Louisiana, Mississippi, and North Carolina—involved more than 153,000 acres. New infestations discovered in these States in 1945 affected approximately 13,000 acres, largely extensions of already known areas. In 1946, however, three new centers of in-

festation were found in Georgia at Eastman, Fort Valley, and Macon, the last two in nurseries that appear to have spread the insect to other points in nursery stock.

Quarantine and control measures designed to prevent spread included supervision of shipments of nursery, farm, mill, and timber products, and also soil, implements, and a countless variety of other materials capable of spreading the pest. More than 260,000 such shipments, about 230,000 of which were carlots, originated in the Gulf Coast States. To keep down beetle populations at critical points so as to reduce the spread hazard, over 86,000 acres were treated one or more times with more than 1,376,000 pounds of insecticides in dust and spray form. Suppressive measures of this type are especially useful around railway yards, storage buildings, schools, and other centers of activity. Equipment has been devised to increase the efficiency of insecticide applications and to reduce costs. Studies of insecticides and spray formulas have likewise contributed much to efficiency and economy and have been especially helpful in working out methods for the large-scale use of DDT in the 1946 program.

It is known that white-fringed beetles produce unusually large numbers of eggs when fed on certain hosts, particularly legumes; that damaging larval feeding on roots is greatest late in the winter or in the spring; and that by choice of crops and proper seasonal planting beetle damage can be greatly lessened. A campaign by State and Federal agencies in western Florida to encourage antibeetle farm-crop planning along these lines has been successful.

### MOLE CRICKET CONTROL IN FLORIDA CONTINUED

The mole cricket control program in Florida was continued in August and September of 1945 for the sixth year with but minor changes. The Bureau undertook to supply and mix the needed poison bait at a central point, the Florida State Plant Board looked after its distribution and its delivery from the central point to the respective counties, and the officials of the several counties concerned accepted responsibility for any damage arising from its use. The bait formula requires the mixing of 8 to 10 pounds of sodium fluosilicate with 100 pounds of wheat bran or steam-rolled wheat. This mixture should be moistened before use and applied at the rate of 120 pounds per acre for seedbeds, or of 30 pounds per acre in two applications for truck crops. The 1945 program used 699 tons of mixed bait, which protected 42,936 acres of fall truck crops on 2,620 farms in 14 Florida counties. Reports from growers and county agents indicated excellent results in mole cricket control.

### D-D SHOWS PROMISE IN CONTROL OF GOLDEN NEMATODE

Control investigations against the golden nematode, undertaken cooperatively by this Bureau, the Bureau of Plant Industry, Soils, and Agricultural Engineering, the New York State Department of Agriculture and Markets, and Cornell University, include soil-fumigation tests, begun in 1944, using various dosages of D-D (dichloropropane-dichloropropylene). Results obtained in 1945 on potatoes planted in the treated plots indicate that, although eradication was not attained even at high dosages, a control of 90 to 99 percent can be expected.

Commercial tubers were found to carry large numbers of golden nematode cysts, and attempts to eliminate them by washing and brushing were not fully successful. Methyl bromide fumigation likewise failed to kill the nematode on tubers when used at dosages noninjurious to the plants, but a 1-percent solution of ammonia at 125° F. held some promise of success.

In addition to maintaining a quarantine to prevent spread of this nematode, New York State has provided for the elimination of all farming operations on known infested land during the calender year 1946, and this Bureau will treat all this infested land with D-D during the summer of 1946.

The discovery, in December 1945, of another potato parasite, the potato rot nematode (*Ditylenchus destructor* Thorne), in Prince Edward Island, Canada, in seed-producing areas which distribute their certified product widely in various States heightens interest in the only other infestation known on this continent, which occurs in a restricted area at Aberdeen, Idaho, and suggests the desirability of making surveys in our major potato areas to discover whether this additional pest may be present elsewhere.

### NEW METHODS REDUCE COST OF DOG FLY CONTROL AT ARMY AIR FORCES CAMPS

In 1946, as in the four preceding years, the Army Air Forces allotted to this Bureau and to the cooperating United States Public Health Service funds to be spent in abating the dog fly (stable fly) nuisance in and around its camps along the northwest shore of Florida. These insects breed in tremendous numbers in wave-deposited windrows of bay grass, and drifting inland their swarms become an almost unbearable scourge to men and animals.

Fortunately treatment of the shore deposits almost completely suppresses larval development in this primary breeding ground. The creosote compound used in earlier treatments is now replaced by DDT preparations. The DDT is mixed with sea water with the aid of an emulsifier, and applied from shallow-draft boats on which are mounted power sprayers which derive their power from air propellers.

In the 1945 season up to eight spray applications were made from July 4 to October 18 on a total of 1,060 miles of grass deposits along 1,676 miles of shore, at an average rate of 202 gallons per mile. Excellent control of dog fly breeding was attained, as indicated by dog fly counts on dairy cattle within and outside the protected area, as well as by Army camp personnel experience. The use of DDT and improved methods of application made it possible to achieve this result at slightly more than one-third the cost of this project in 1944.

### COOPERATION OF GROWERS AIDS IN PEAR PSYLLA CONTROL

In 1945 pear growers in the State of Washington and Bureau crews applied at least four sprays to all properties found infested with the pear psylla in 1944 and 1945, and to all trees within a half-mile radius of these properties. Approximately 306,000 trees were inspected on 28,000 properties, and 73,200 lineal feet of sticky bands were exposed on pear trees in north-central Washington and some other areas during the winter of 1945–46, to delimit the area of infestation and evaluate the effectiveness of the spray program. These band-

proved to be effective in trapping overwintering adults. Their use permits survey and inspection work throughout most of the year.

The foregoing surveys show no further extension of the general areas of infestation in the Northwestern States during the past year, and a reduction in the number of infested properties from 321 in 1944 to 264 in 1945. No infestation is now known in Yakima County, the major pear-producing district of the Northwest. The number of infestations decreased further in Spokane and other eastern Washington counties, and no infestations were found in Lincoln, Adams, Franklin, and Benton Counties in Washington, or in Boundary County, Idaho. In Chelan, Douglas, and Okanogan Counties, Wash., some increase was found in 1945 and a further increase in the spring of 1946.

During the year the pear psylla became widely distributed in the Okanogan Valley of British Columbia, and more than 250,000 additional pear trees were exposed to infestation. Therefore, the Dominion of Canada and the Province concluded that any further attempt at eradication in that general area was impractical with the facilities at hand. British Columbia is recommending that pear growers continue a general program of suppression in 1946.

### FUMIGATION PROGRAM AGAINST HALL SCALE CONTINUES

Further intensive survey and inspection for Hall scale during the past year indicated that the infested area near Chico, Calif., remained practically the same as in the previous year. Early in July 1946, however, a new infestation was found at Oroville, Calif., about 20 miles from Chico. The extent of this infestation is not yet known. The fumigation program initiated the previous year was intensified, 1,552 trees being treated with hydrocyanic acid gas during the winter of 1945–46. Even though a complete kill appeared to have been obtained at the time, a few live scales were found in 1945 on trees fumigated the winter before. Eventual eradication by fumigation appears possible, however, in view of the general over-all effectiveness of the treatment, and equipment is being assembled for a more intensive fumigation program. Supplementing fumigation, two applications of oil sprays were made to trees on all known infested properties. Work on this problem was conducted in cooperation with the California State Department of Agriculture.

### PHONY PEACH AND PEACH MOSAIC DISEASE CONTROL CONTINUES TO SHOW ENCOURAGING RESULTS

Federal-State cooperation in control of phony peach and peach mosaic diseases has continued the objectives of previous years—to prevent spread of these virus diseases in nursery stock, to eliminate them from lightly infested States, and to protect commercial orchards from excessive losses of trees—with the hope of finally reducing incidence to a minimum or eliminating these diseases from large areas.

Nursery inspection covered 357 nurseries containing nearly 13,000,000 trees, with their 1-mile environs, and 35 budwood sources and their environs. Only 3 nurseries failed to qualify for interstate shipment. As a result of these efforts over a period of years there is

no evidence that these diseases are being spread through nursery stock.

Orchard inspection for both diseases in 1945 was conducted in 183 counties in 14 States, covering 28,537 properties containing nearly 10,000,000 trees. There were found 75,978 phony-infected peach trees and 7,200 infected with mosaic. Practically all these trees were removed.

Orchard inspection for phony peach originally covered 17 States, of which 7 have been dropped after showing no phony disease for 3 years. In 7 others the incidence of this disease has constantly decreased during the years of control work. No phony disease was found in Tennessee during 1945. In Georgia and Alabama limited inspection efforts are apparently holding the disease in check.

There has been a continuing, though not pronounced, drop in peach mosaic incidence in recent years, and the area of infection is being reduced from year to year.

### DUTCH ELM DISEASE SPREADS WHERE DISEASED TREES ARE LEFT STANDING

#### SURVEY OF NEW AREAS STARTED

Two scoutings, covering some known diseased territory plus a 20-mile border zone, were made in the States cooperating in the Dutch elm disease control program—Connecticut, Delaware, Indiana, Maryland, Massachusetts, Vermont, and Virginia. These surveys were continued to locate disease as well as elm material infested with bark beetle carriers of the fungus, for removal by local or State agencies. There being no organized control programs in the infected sections of Kentucky, New Jersey, New York, Ohio, Pennsylvania, and West Virginia, surveys in these States were confined to determining the outermost limits of the disease, no attention being paid to known infected districts. In New York, State authorities advised municipalities on control measures in a portion of the invaded territory.

Spread of infection as determined by scouting in known infected States and adjacent territory was found to be nominal in Connecticut and Massachusetts. Spread into Vermont and Kentucky from adjoining infected territory constituted first records for these States. Extension of the disease into northern Virginia from the Frederick, Md., area was also significant.

Limited scouting in New York showed extensions still farther northward from the Hudson River Valley and from the still separate but seemingly parallel column of infection stemming from the original Binghamton area. Disease was found in some of the corridor townships separating these areas. These northward extensions are within 25 miles of Lake Ontario.

Scouting in Pennsylvania showed widespread infections in the Susquehanna River Valley. With only a short break between the Susquehanna River Valley and the Binghamton areas, this forms an almost continuous chain from the St. Lawrence River Basin to Lancaster County, where the chain joins the older infected area in the southeastern part of Pennsylvania. This spread roughly describes an arc 35 miles northwest of the main Pennsylvania disease area.

Of major importance was the discovery of hundreds of diseased trees over a wide area surrounding Cincinnati, Ohio, and extending

into Kentucky. The invaded territory is approximately 65 miles wide and 55 miles deep. The eastern extremity is within 30 miles of the older Athens, Ohio, area, where peripheral scouting showed disease spread in roughly one tier of townships during the year, both in Ohio and in contiguous West Virginia districts.

In Indiana the fungus was found in only one additional township adjacent to the isolated Indianapolis area.

There was no recurrence of the disease in the Cleveland, Ohio, Cumberland or Baltimore, Md., or Portsmouth, Va., sections, where control measures against isolated infections were practiced several years ago.

### IMPROVEMENTS MADE IN LABORATORY CULTURE OF ELM BARK AND WOOD

Operation of a culture laboratory was continued as the only practical means of determining the presence or absence of the Dutch elm disease fungus in specimens from trees exhibiting disease symptoms or infested with bark beetles. This laboratory serves both the scouting and research units of the Bureau, as well as State agencies and private individuals interested in diseased-tree removal.

Specimens cultured during the year numbered 10,322. More than 50 percent of them were samples of bark and wood squares which require a longer period for incubation and a greater number of petri dishes than twig samples. The disease fungus was isolated from 2,650 of these specimens. Comparable figures for 1945 were 11,658 specimens and 1,366 positive cases.

### EXPERIMENTAL CONTROL PLOTS CONTINUED

Previously established experimental control, or demonstration, plots were continued to determine measures that might be taken by local communities to preserve valuable elms despite the presence of the disease in the community.

In the plot at Morristown, N. J., work was continued to check on the developing disease-insect conditions and the effect of such conditions on adjoining areas. An inner zone with a 20-mile radius had all diseased and critical bark beetle material removed before it became a hazard to adjoining trees, and outside of this a zone 1 mile in depth was used as an observation zone. Forty-two cases of the disease were found in the outer zone and 192 diseased trees in the inner zone in 1945. The removal of so many diseased trees presented such a problem that in some instances felled trees and infested material were sprayed with monochloronaphthalene to prevent beetle emergence.

In the plot at Princeton, N. J., 122 diseased trees were discovered in the 1-mile outer zone during the 1945 scouting season. All critical beetle material was removed before the beetles emerged. Bark beetle traps were created in the 2-mile zone by killing 833 wild elms with chemicals and by bringing into the plot 981 elm bolts from chemically treated trees. The number of diseased trees found in the 2-mile zone increased from 93 in 1944 to 323 in 1945, making any further attempt at control by use of trap trees impracticable.

At the Marietta, Ohio, plot there is an overlapping of two elm tree diseases, the Dutch elm disease and the phloem necrosis. Within the

control zone 15 trees were confirmed as infected with phloem necrosis, an increase of 5 over the previous year. Four cases of the Dutch elm disease were confirmed from this zone. There were also 4 confirmations reported from the protective zone.

At 26 small study centers where no sanitation work was performed, disease increases of over 1,000 percent have occurred since 1943.

Early in May 1946, 494 elms in four experimental plots in northern New Jersey urban areas were sprayed with DDT. These plots will receive another coverage with DDT in July, and will be kept under observation to determine whether they have been protected from attack by bark beetle vectors of the Dutch elm disease.

## BARBERRY ERADICATION BRINGS DIVIDENDS IN INCREASED GRAIN CROPS

### FARMERS ENTHUSIASTIC OVER RESULTS

Cooperative barberry-eradication work was continued during 1945 on the same basis as in the previous calendar year. Priority was given to work in grain-producing territory infested with scattered rust-susceptible bushes that were menacing growing crops and to reinfested territory requiring prompt attention to destroy barberry regrowth before it was old enough to produce seed. This rework is timed to keep the barberries in treated areas on the decline toward ultimate elimination. Eventually as these areas are rid of rust-susceptible barberries, they become a part of the territory in which work has been completed except for such limited follow-up activities as are required to maintain it in this condition.

Increased yields and better quality small-grain crops follow in the wake of barberry-eradication work. Farmers in parts of Pennsylvania and Virginia where the initial eradication work has been completed obtained such results from the same varieties without a change in farm practices. In Pennsylvania records from 168 farmers showed that average oat yields had increased 123 percent during the 5 years following barberry eradication. In Virginia 68 farmers showed that their average yields of wheat had increased 82 percent. As a result, neighboring farmers have asked for assistance in eradicating the barberries from their lands. Farmers in other sections where eradication work has been done report that they have not been troubled with rust since this program has been in operation.

### BARBERRY ERADICATION ACCOMPLISHED PRIOR TO AND DURING 1945

There are 1,043,886 square miles in the stem rust control area of the United States (fig. 2). A large part of the area has been freed of all known rust-susceptible barberries, but 295,252 square miles are still in need of eradication. Of the area still to be worked, 62 percent requires an inspection of yards, fence rows, ditches, orchards, and woodlots in rural and urban areas. The other 38 percent requires systematic crew coverage one or more times to eradicate the barberries. Within the remaining work areas there are 77,680 former barberry locations that must have one or more rechecks before they can be added to the territory classed as free of these bushes.

Field operations in 1945 resulted in the eradication of barberries on areas totaling 7,815 square miles. In this work 10,066,871 bushels were destroyed on 785 new and 1,647 reinfested properties. Of the barber-

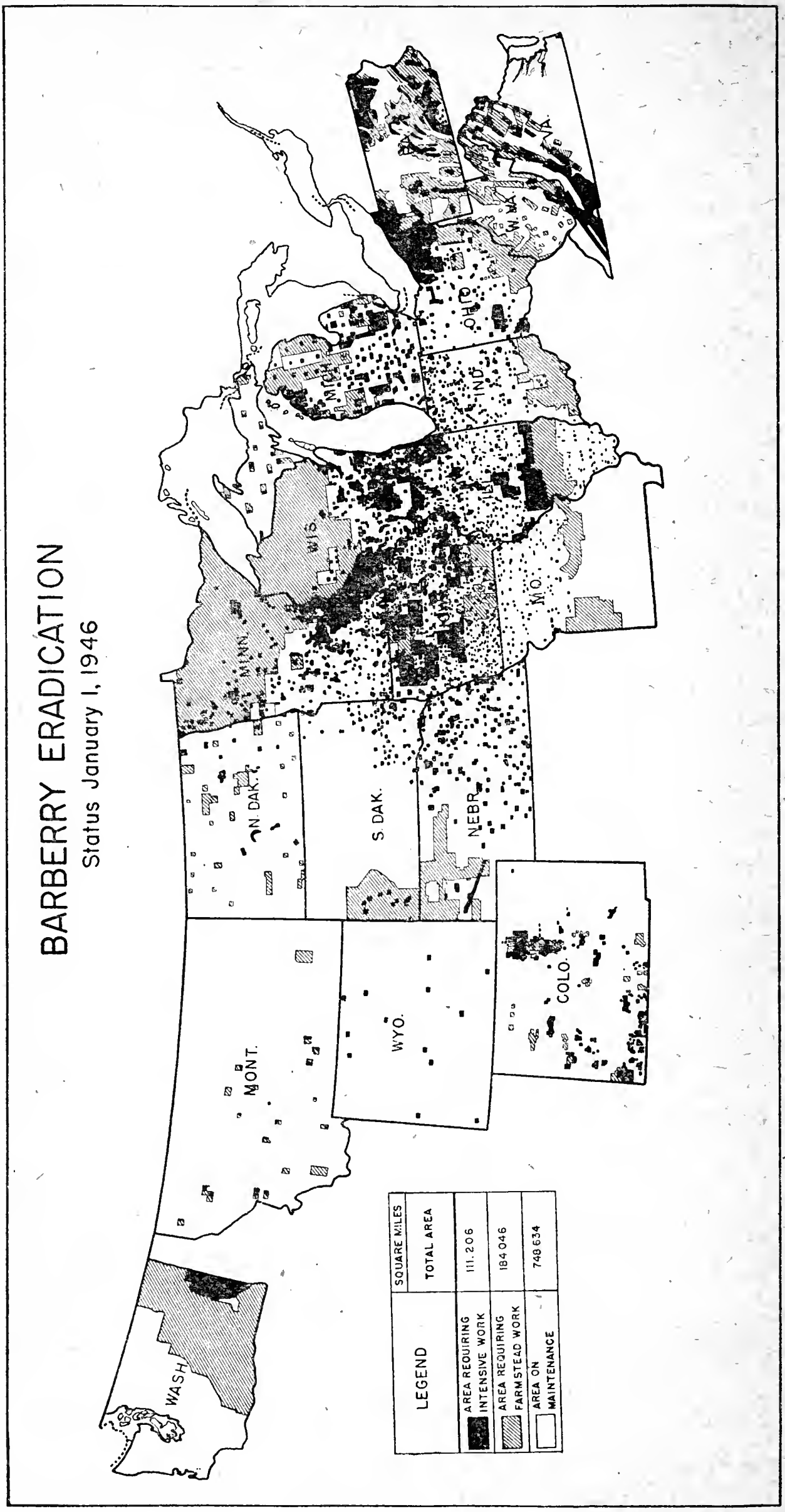


FIGURE 2.—Status of barberry eradication in the United States, January 1, 1946.

ries destroyed, 10,025,880 were native species that occur in Colorado, Virginia, and West Virginia and 40,991 were planted and escaped *Berberis vulgaris* bushes. A summary of the eradication work, by States, is shown in table 1.

TABLE 1.—*Results of barberry eradication, calendar year 1945*

| State | Area surveyed | Properties cleared | | Bushes destroyed | | |
|---|---|---|---|---|---|---|
| | | New | Old | *Berberis vulgaris* | Native species [1] | Total |
| | *Square miles* | *Number* | *Number* | *Number* | *Number* | *Number* |
| Colorado | 189 | 23 | 88 | 90 | 833,645 | 833,735 |
| Illinois | 385 | 53 | 87 | 1,544 | ---------- | 1,544 |
| Indiana | 290 | 10 | 35 | 106 | ---------- | 106 |
| Iowa | 489 | 37 | 165 | 2,705 | ---------- | 2,705 |
| Michigan | 1,283 | 194 | 399 | 4,291 | ---------- | 4,291 |
| Minnesota | 622 | 19 | 60 | 2,234 | ---------- | 2,234 |
| Missouri | 173 | 16 | 17 | 94 | ---------- | 94 |
| Montana | 706 | 0 | 6 | 10 | ---------- | 10 |
| Nebraska | 296 | 6 | 5 | 20 | ---------- | 20 |
| North Dakota | 444 | ---------- | 1 | 16 | ---------- | 16 |
| Ohio | 377 | 59 | 110 | 3,284 | ---------- | 3,284 |
| Pennsylvania | 13 | 9 | 271 | 13,781 | ---------- | 13,781 |
| South Dakota | 74 | 0 | 0 | 0 | ---------- | 0 |
| Virginia | 76 | 65 | 104 | 0 | 4,980,561 | 4,980,561 |
| Washington | 774 | 238 | 22 | 10,957 | ---------- | 10,957 |
| West Virginia | 56 | 6 | 73 | 0 | 4,211,674 | 4,211,674 |
| Wisconsin | 1,568 | 50 | 204 | 1,859 | ---------- | 1,859 |
| Wyoming | 0 | 0 | 0 | 0 | ---------- | 0 |
| Total | 7,815 | 785 | 1,647 | 40,991 | 10,025,880 | 10,066,871 |

[1] *Berberis fendleri* A. Gray and *B. canadensis* Mill.

All properties where fruiting bushes are destroyed must be worked subsequently one or more times to destroy any new growth from seeds in the soil or from root fragments. The rework interval is scheduled to preclude fruit production on new growth and subsequent local reinfestation of the area. During the war it was not feasible to keep the rework up to date, and reinfestation has occurred in some areas. For example, of the 1,647 properties found reinfested, 922 had fruiting bushes. Deposition of seed by these bushes extends the period required to free these properties of barberry.

State and local agencies maintained a keen interest in the cooperative work, and several of the 18 participating States increased their appropriations for this work. The total expenditures by cooperators during the calendar year 1945 exceeded those for the previous year by more than 16 percent.

### LITTLE DAMAGE CAUSED BY STEM RUST

Stem rust of wheat caused very little damage in 1945, although weather conditions were favorable for its development and spread. The south-to-north spread was of little importance, because an unusually small amount of the rust overwintered in the South. To determine the number and distribution of physiologic races of wheat stem rust, 1,032 isolations were made from 702 collections. Only three races—numbers 56, 17, and 38—were significant in rust development, although 23 races and biotypes were identified. An additional 46 isolates were obtained from 34 aecial collections; these comprised 21 races and biotypes.

Stem rust of oats was somewhat more prevalent. However, in the northern oat-growing States losses did not exceed 3 percent, and for the country as a whole the losses were light. Vicland, Boone, Tama, and certain other recently introduced resistant oat varieties showed some injury where races 8 and 10 were present. Race 7, which attacks White Tartar, used as a stem-rust-resistant parent in oat breeding, was found only in New York and Minnesota.

### NURSERY INSPECTION

Applications to ship *Berberis* and *Mahonia* plants under the provisions of Federal Quarantine No. 38 were received from 42 growers. Permits were granted to 26 growers without inspection on the basis of previous inspection records and to 16 growers following inspection in 1945. Kansas issued a State quarantine on stem rust and has been included as one of the protected States under Federal Quarantine No. 38. Nurserymen were asked (1) to make sure their seed and "liner" stock of *Berberis thunbergii* was free of contamination; (2) to destroy susceptible species or varieties that might be mixed in with their immune or highly resistant stock, and (3) to check *B. thunbergii* stock carefully and rogue out any hybrid or "off-type" plants that might be susceptible to stem rust. State inspection officials encouraged nurserymen to grow only immune or highly resistant varieties or species and to make sure that *B. thunbergii* stock was produced from pure seed.

### CHEMICAL ERADICATION EXPERIMENTS

Ammonium sulfamate and 2,4-D (2,4-dichlorophenoxyacetic acid) were tested as barberry herbicides, and new techniques were tried for the application of sodium chloride and sodium chlorate. The preliminary readings of the ammonium sulfamate test plots show this chemical to be extremely toxic. Compared with an application of 100 pounds of common salt, less than ½ pound of this chemical is required, at a cost of 10 cents as compared with an average of 60 cents for salt. The 2,4-D treatment gave partial to complete defoliation and severe stem cracking and burning, but it does not appear to be so promising as ammonium sulfamate. Dry sodium chloride and sodium chlorate, which had been tried on an experimental basis in previous years, were used this year in the field for destroying *Berberis canadensis*. The dry salts are equally as effective as brine, but the application of the dry chemical is less time-consuming.

### WHITE PINE BLISTER RUST CONTROL

Encouraging progress in the control of this disease was made before the war with emergency relief labor, but since then only a holding program has been practicable and some ground has been lost. With an adequate work program for the next few years, this set-back can be overcome and control can be established on a firm basis that will assure the continued production of the white pines in protected areas. Present domestic and world needs, as contrasted with existing limited supplies of lumber, indicate the importance of preserving and protecting this forest resource.

The initial removal of ribes has been completed on about 80 percent of the approximately 28,000,000 acres of control area in the cooperating States, and control of the rust is now considered to be well es-

tablished on 37 percent of this acreage. On the remaining area the work has been increased and made more difficult by changes in the forest cover caused by the harvesting of over 11,000,000,000 board feet of white pine lumber for war uses during the period 1940–45. This is twice the average annual rate of cut for the previous 5-year period. As the regeneration of pine and ribes occurs at about the same time, ribes-eradication measures must be applied promptly to these cut-over areas to prevent the loss of young growing stock to the disease.

Priority in ribes eradication was given to required rework and to areas of high rust hazard needing initial protection. The work was carried on in cooperation with Federal, State, and private agencies under the leadership and technical direction of the Bureau. The results by regions are shown in table 2.

TABLE 2.—*Ribes-eradication work of all cooperating Federal, State, and private agencies for calendar year 1945*

| Region | Initial eradication | Reeradication | Total | Effective labor | Ribes destroyed |
|---|---|---|---|---|---|
| | *Acres* | *Acres* | *Acres* | *Man-days* | *Number* |
| Northeastern | 82,422 | 414,825 | 497,247 | 31,607 | 2,147,268 |
| Southern Applachian | [1] 218.881 | 35,770 | 254,651 | [2] 12,467 | 1,389,317 |
| North Central | 83,907 | 69,253 | 153,160 | 23,299 | 3,043,605 |
| Northwestern | 12,415 | 38,863 | 51,278 | 65,921 | 6,403,120 |
| Pacific Coast | 23,003 | 39,543 | 62,546 | 51,624 | 5,955.519 |
| Total | 420,628 | 598,254 | 1,018,882 | 184,918 | 18,938,829 |

[1] 213,123 acres found ribes-free.
[2] 1,904 man-days blocking out ribes-free acreage.

The acreage of rework greatly exceeded that of initial eradication and indicates the effort made to maintain control of the disease on protected areas. About 5,500 persons were employed on ribes eradication at the peak of the season, and 88 camps were operated in remote forest areas. Of these camps 79 were located in the West. Other control work included the eradication of 48,191 ribes from 8,688 acres in the environs of 19 nurseries to provide protection for over 43,650,000 young pines and the removal of cankers from 292,392 infected white pines to save them from being killed by blister rust. State and local agencies increased their contributed funds by about $85,000 for the fiscal year 1946, the total State and private aid amounting to over $364,000.

### SPREAD OF BLISTER RUST IN 1945

In northern California the known range of blister rust was extended eastward into the southern Warner Mountains, Modoc County, where the disease was found for the first time on *Ribes petiolare* within the Modoc National Forest. Climatic factors necessary for the spread and intensification of the rust in the Pacific coast region were generally unfavorable, but in the area between the East Fork of Indian Creek and the Slater Butte Road in the western part of the Klamath National Forest *R. sanguineum* bushes had from 50 to 100 percent of their leaves infected with blister rust, whereas elsewhere on this forest ribes infection was generally light.

In the Sierra Nevadas numerous infected ribes were found at the southern end of the Shasta and the northern end of the Lassen National

Forests, where the rust appeared to have intensified on ribes to a greater extent than it had elsewhere. Infected ribes leaves were obtained from the southern part of the Eldorado National Forest for the second consecutive year, and four new pine-infection centers of 1938 origin were located and destroyed on the Lassen, Plumas, and Shasta National Forests within the previously known infected areas.

In the Northwestern States no blister rust infection was found on white pine or ribes beyond its previously known distribution. Heavy infection was found on the leaves of six *Ribes petiolare* bushes on Clematis Gulch and Glen Creek in the Mammoth area, in the northwestern portion of Yellowstone National Park. This confirms the original report of the disease on *R. petiolare* leaves from Clematis Gulch in 1944 and may be indicative of undiscovered infected white pine in that general locality. Since 1941 there has been no serious general build-up of the disease on white pine. Weather conditions in the spring of 1945 were ideal for spread of the rust from pine to ribes, but the heavy initial infection of ribes was largely dissipated by a long period of dry, hot weather continuing from late June to late August, which kept the spread of the disease from ribes to pine from developing into the proportions observed in 1937 and 1941.

In the North Central region ribes infection was found for the first time in 22 counties in 4 States, as follows: Carroll County, Ill.; Elkhart and Steuben Counties, Ind.; Buena Vista, Carroll, Clay, Dallas, Emmet, Greene, Hamilton, Hardin, Humboldt, Mahaska, Marion, and Warren Counties, Iowa; and Columbiana, Crawford, Delaware, Franklin, Morrow, Muskingum, and Perry Counties, Ohio. Infected white pines were found for the first time in Crawford and Ogemaw Counties, Mich. As in 1944, the greatest extension of the rust into new areas occurred in Iowa, where infected ribes were found in 12 counties for the first time. Considerable variation in the intensity of rust development on ribes was noticeable in Illinois, Indiana, Ohio, and the lower portions of Michigan and Wisconsin where ribes infection was light and relatively scarce, but in Iowa, Minnesota, and the upper portions of Wisconsin and Michigan ribes infection was normal. The amount of infection on white pine has increased considerably in northern portions of the region during recent years, and numerous cankers of 1941 and 1942 origin were observed in 1945.

In the southern Appalachian States two centers of infected white pines were discovered in Grayson County, Va. These were the first found in southwestern Virginia, and at the time were the most southern pine infection centers known in the region. Late in the summer, however, a small area of diseased white pine was discovered in northwestern Ashe County, N. C. This is the first area of infected white pines found in the State. Blister rust infection was reported for the first time from Anne Arundel and Cecil Counties, Md., on cultivated ribes.

In the Northeastern States blister rust is generally distributed, and ribes eradication has been progressively extended within the white pine area over a period of many years. Control of the disease has been established in those parts of the worked area on which these bushes have been so reduced that a serious rust hazard to the pines no longer exists. Continued suppression of ribes will keep them on the decline and maintain effective control of the disease.

The spread of the rust from ribes to pines has continued in unprotected areas, as well as in those parts of the protected areas where these bushes have not been kept sufficiently suppressed to control the disease. The spread in these protected areas is due to unavoidable delay in scheduled reworkings and to logging and other disturbances which bring about the germination of pine and ribes seeds. In general, the prevailing effectiveness of the ribes eradication work in controlling the disease is shown by the relative scarcity of new cankers on white pines in protected areas.

Most of the younger pines infected prior to initial control work have been killed by the rust and have gradually disappeared from the stands. Meanwhile, damage resulting from early infection of the older and larger pines, which are killed more slowly by the disease, has become increasingly apparent. This is manifest in many stands by a growing number of dead and dying trees in the older age classes. Damage of this sort is most prevalent in Warren and Essex Counties, N. Y., the upper Connecticut River Valley in New Hampshire and Vermont, and in most sections of Maine outside of York and Cumberland Counties.

### CONTROL METHODS FURTHER DEVELOPED AND IMPROVED

Significant improvements were made in herbicidal methods for ribes eradication and in the coordination of control methods with pine management. The usefulness of ammonium sulfamate and 2,4-D for ribes-eradication work was established by laboratory, greenhouse, and field tests. For ammonium sulfamate the effective dosage, concentration, method of application, and time of year to apply have been determined for all species of *Ribes* of importance in blister rust control work in the Pacific Coast and Northwestern regions. Under specified conditions ammonium sulfamate can now be recommended for practical eradication of *binominatum obracteosum*, *cereum*, *erythrocarpum*, *inerme*, *lacustre*, *nevadense*, *petiolare*, *tularense*, and *viscosissimum*. The effective dosage ranges from ½ pound to 3 pounds per milacre, depending on the species to be treated.

Of the 16 *Ribes* species on which 2, 4-D acid (or its analogs) has been tested, *petiolare* and *roezli* appear to be highly susceptible, *cereum*, *cruentum*, *nevadense*, *sanguineum*, and *viscosissimum* are moderately susceptible and *binominatum*, *erythrocarpum*, *glutinosum*, *inerme*, *lacustre*, *lobbi*, *menziesi*, *montigenum*, and *tularense* are moderately to highly resistant. Effective results with 2, 4-D on susceptible *Ribes* species are obtained only when the plants are making active vegetative growth. For *petiolare* and *roezli* 100-percent kill of test plants has been obtained by spraying the aerial plant parts with the aqueous sodium salt of 2, 4-D acid containing the equivalent of 500 p. p. m. (0.05 percent) of the 2, 4-D acid. With the possible exception of a combination of 2, 4-D (salt or acid) with furfural, resistant species have been unaffected by the several 2, 4-D formulas so far tested.

Field trials of power sprayers in applying ammonium sulfamate and 2,4-D to ribes in California and Idaho indicated that the use of these herbicides may speed the establishment of control on cut-over lands. The results of ecological studies in Idaho are being put to practical use in evaluating ribes regeneration in relation to western white pine logging and management practices, and surveys on proposed

timber sales have been made to coordinate cutting practices with methods of blister rust control. Previously described methods for extracting and identifying ribes seeds from samples of forest soil and duff have provided useful information about ribes regeneration potentials in the Pacific coast, northwestern, and southern Appalachian regions. These methods also are applicable to seeds of other plants.

## QUARANTINE AND REGULATORY ACTIVITIES

### ENFORCEMENT OF JAPANESE BEETLE QUARANTINE

#### REVISION OF QUARANTINE REGULATIONS

Under a revision of the Japanese beetle quarantine regulations effective March 18, 1946, there was added to the regulated area the election district of Oldtown (No. 2), Allegany County, Md., the townships of Marion, Franklin County, and Madison, Licking County, Ohio, and the town of Shenandoah, Page County, Va. No other changes were made in the quarantine regulations. Shippers, agents of common carriers, and other interested individuals were informed of this modification through a supplement to the shipper's guide and a revised colored map of the affected areas.

#### HIGHWAY INSPECTION SERVICE

Highway inspection stations were established during 1945 on seven south-bound highways in Virginia. Four of these stations were opened on June 18, two more on June 19 and 21, and the seventh on July 11. Six were closed on August 30. The largest station, on U. S. Route 1, was kept open until September 12. Total personnel consisted of 22 inspectors.

Inspectors examined motortrucks and removed all Japanese beetles found. They also supervised the cleaning of such vehicles and the disposal of debris that might contain Japanese beetles. At the two major stations there were facilities for inspecting and certifying produce.

During the season 69,577 trucks were inspected. Of this total 68,753 were transporting nonquarantined products, 450 had proper certification of their loads, and 374 were carrying uncertified produce. From 98 empty trucks examined, 494 living Japanese beetles were removed.

The loads carrying uncertified produce on 303 of the trucks were inspected and certified at the road stations or at inspection platforms nearby. Eleven returned their uncertified produce to the regulated area. Permits were issued to 59 trucks to allow their movement to isolated regulated areas. One trucker insisted on proceeding in violation of the regulations.

A produce dealer of Harrisonburg, Va., who deliberately violated the regulations by transporting uncertified fruits and vegetables from Washington, D. C., to his place of business, was prosecuted in the United States district court and fined $300.

Cooperative arrangements with Army and Navy officials were continued to try to prevent spread of the beetle in airplanes leaving service fields within the heavily infested areas. Compartments in such planes were treated with DDT-pyrethrum aerosols furnished by the Bureau. Clothing of passengers and crew was inspected as they entered planes.

Commercial air lines also continued their cooperative inspection of passengers' and crews' clothing to remove beetles that might be taken into planes. They also inspected baggage, mail, and other parcels, as well as the interior of cabins. Cooperative experiments are in progress to develop treatments that will have residual effect against any hitch-hiking beetles, and also to develop an aerosol treatment that may be released while passengers are in the plane just prior to take-off.

### IMPROVED TREATMENTS FOR CERTIFICATION OF NURSERY STOCK

Following considerable experimental work, authority was granted on March 21, 1946, for the use of DDT for treating soil in nursery plots and potting soil as a means of obtaining certification of plants grown in such soil. This treatment extends to plots either with or without growing plants. It is anticipated that this type of treatment, requiring the use of only 25 pounds of technical DDT per acre, will eventually supersede the previously required treatment of plots with lead arsenate at the rate of 1,000 pounds per acre. This new treatment may prove to be one of the greatest advances yet made in aiding nurseries to obtain certification of their plants.

A new chemical treatment was authorized on November 2, 1945, to afford an easier method of obtaining certification of bare-rooted, woody plants. Plants with only small amounts of soil adhering to the roots are immersed for 10 seconds in an emulsion containing ethylene dibromide and ethylene dichloride. After a 24-hour holding period they are eligible for shipment. Previously growers had met the requirements for freeing plants from soil largely by shaking off loose dirt and then either washing them under considerable pressure or sloshing them about in a trough or tub of water, a procedure which involved considerable delay in shipment and expense for labor and equipment.

During beetle flight in the summer of 1945, from 1 to 4 scoutings were made of 1,100 nurseries and greenhouse units or subdivisions in which infestations had not previously been determined. Infestations were found in 65 of these, thereby placing them in an infested status.

There was an 80-percent increase in total plant items certified during the year. The number of plants inspected and certified from infested establishments and the number chemically treated before certification follow:

| | *Total number of plants* | |
|---|---|---|
| | *1945* | *1946* |
| Inspected and certified | 26,000,000 | 47,000,000 |
| Chemically treated before certification: | | |
| By methyl bromide fumigation | 1,200,000 | 1,600,000 |
| With ethylene dichloride | 800,000 | 1,100,000 |

Material shipped under certification from infested establishments included, in addition to the 47,000,000 plants indicated in this chart, 250 tons of soil and manure. Furthermore, 22,267,956 plants were certified for establishments determined as uninfested, and 39,508,175 plants and 197 tons of soil and manure were certified for movement between dealers within the regulated zone.

A total of 332,736 certificates of all types were issued to cover quarantined products moving to nonregulated territory.

Investigations were made of 307 apparent violations of the quarantine regulations. Most of these related to shipments of uncertified plants intercepted by transit inspectors stationed at mail and express terminals.

### CERTIFICATION OF FRUITS, VEGETABLES, AND CUT FLOWERS

Restrictions on fruits, vegetables, and cut flowers in 1945 became effective on June 7 in the southernmost sections of the heavily infested area, and on June 21 in the remainder of the area. Green corn remained under regulation until September 12 and cut flowers until September 30. With these exceptions, all seasonal restrictions throughout the area were lifted at the close of August 30.

During the fiscal year 1,292,777 packages of fruits and vegetables were certified. This was an 18-percent increase over the amount certified during the previous year. From the farm products given visual inspection 150 living Japanese beetles were removed. Certification of farm produce involved the fumigation with methyl bromide of 3,035 loaded refrigerator cars and 28 loaded motortrucks. Fumigation of loaded refrigerator cars was concentrated at Cape Charles, Va., Wilmington, Del., and Philadelphia, Pa., cars for diversion only being fumigated at Pitcairn, near Pittsburgh, Pa. During the summer 12,874 packages of cut flowers were also given visual inspection and 150 beetles were collected.

### CERTIFICATION OF PRODUCTS UNDER THE GYPSY AND BROWN-TAIL MOTHS QUARANTINE

A major revision of the gypsy moth regulated area became effective on October 10, 1945. Areas that had been previously designated as generally and lightly infested were merged into one generally infested area. In addition, a suppressive area was created to include most of the barrier zone in the western sections of Vermont, Massachusetts, and Connecticut, and also adjacent territory in northeastern New York, where infestations had developed to such an extent that restrictions were warranted on host material moving out. At the same time provisions were made for protecting this sparsely infested area from reinfestation so that control measures might continue to be practiced where feasible. This extension adds approximately 9,100 square miles to the regulated area, or a 25-percent increase in territory.

To meet shipping requirements in the suppressive area, new inspection districts were created, and inspectors were assigned to furnish adequate inspection facilities to shippers of regulated products. Fifty-seven commercial shippers in New York and 13 shippers of marble and slate in Vermont were placed under permit.

Individual shipments certified during the year numbered 245,536, an increase of 58 percent over the shipments certified in the previous year.

Through the inspection service afforded by this project, the forest-products industry was enabled to ship under certification during the year 190,873,076 board feet of lumber and 85,252 cords of pulpwood. Large quantities of stone and quarry products, including 8,432 tons of granite and 29,262 individual pieces of granite, were inspected. From these products inspectors removed and destroyed 2,187 egg clusters, 490 larvae, and 183 pupae of the gypsy moth. This was an increase of more than 50 percent over egg clusters intercepted during the previous year.

Various shippers took advantage of newly authorized methyl bromide fumigation to obtain certification of their products. Carload

shipments of waste wood chips, fuel wood, and rough-edge lumber were certified by this procedure. Several shippers purchased their own fumigation equipment.

Moving of temporary-housing facilities from the infested area to distant points occasioned considerable checking. This involved inspection and certification of portable houses, Quonset huts, and camp trailers. In one instance inspection of four trailers to be driven to Omaha, Nebr., resulted in the removal of 32 egg clusters.

An extensive survey was made of tourist camps and trailer sites to secure cooperation of owners in cleaning up surrounding gypsy moth infestations. Scattered infestations were found at a few of the sites. Trailer owners were informed of the danger of spreading the gypsy moth on their trailers and camping equipment. Arrangements were made to inspect any such equipment being moved to noninfested points.

There were also increased inspection activities in all nurseries. During the peak of the spring shipping season inspectors were hard-pressed to take care of the many additional requests for inspection.

Many granite quarries in Vermont and New Hampshire reopened after several years of inactivity. Requests for certification of their products from premises where moth-control work had been neglected increased inspection loads in a number of districts.

Road patrol on the border of the generally infested area was started in mid-September and continued throughout the fiscal year. This patrol was effective in compelling truckers to obtain inspection of quarantined products that might otherwise move contrary to regulations. A 16-hour-per-day schedule was maintained during the heavy truck movement of Christmas trees. Road inspectors were responsible for the interception of 70 potential violations of the regulations. During the year investigations were made of 229 apparent violations.

Christmas-tree certification during November and December was largely on the basis of methyl bromide fumigation of boxcar and truck loads. This method now permits certification of trees from any infested area. Under the former tedious, visual-inspection methods inspections were limited to trees from the lightly infested area because they were the only ones that could be safely inspected. Trees from the heavily infested section were prohibited movement. Two federally owned portable boxcar fumigation units were in use at Barre and Chester, Vt. Fumigation operations there were performed either by the tree owners or by employees of the State Department of Agriculture. Throughout the regulated area 100 carloads and 2 truckloads of Christmas trees were fumigated. In addition there were 32 fumigations in specially constructed sheds.

Other products shipped in large quantities that were inspected and certified during the year were the following:

| | | |
|---|---|---|
| Logs, piles, poles, ship knees, and ties | pieces | 884, 590 |
| Shavings | bales | 84, 693 |
| Cable reels | number | 37, 595 |
| Miscellaneous forest products | pieces | 146, 463 |
| Shrubs | number | 2, 722, 362 |
| Deciduous trees | do | 197, 545 |
| Evergreen trees | do | 1, 196, 860 |
| Seedlings and small plants | do | 4, 763, 343 |
| Boughs, balsam twigs, and mixed greens | boxes or bales | 78, 008 |
| Christmas trees | number | 290, 887 |
| Feldspar | tons | 35, 484 |

### ENFORCEMENT OF DUTCH ELM DISEASE QUARANTINE COMPLICATED BY PRESENCE OF PHLOEM NECROSIS

The finding of Dutch elm disease in Ohio and West Virginia territory already invaded by phloem necrosis, another virulent disease of elms, has further complicated enforcement of the Dutch elm disease quarantine. It has been difficult to devise an enforcement policy that could be considered consistent and effective when applied where both diseases occur. The vectors responsible for spreading phloem necrosis have not yet been determined, nor can it be recognized in its early stages. Consequently, it is problematical whether even an outright embargo on elm material would effectively check the disease. This situation has also hampered revision of the quarantine regulations in other States.

### CERTIFICATION OF CITRUS FRUITS UNDER THE MEXICAN FRUITFLY QUARANTINE

Citrus-fruit production in Texas in the area regulated under Quarantine No. 64 increased somewhat over that of the previous year. The total production amounted to 28,218,816 80-pound boxes. Although there was only a small increase in the number of infestations, the amount of fruit sterilized before shipment was almost twice the amount treated during the previous season. Early in the harvesting season the regulations were revised to permit the movement of fruit after inspection but without certification. This revision eliminated a large amount of record keeping, and made it possible for the same number of inspectors to give closer attention to field inspection. No new infestations were found outside the regulated area.

Data on the amount of fruit produced, sterilized, and processed and the number of fruitfly infestations found in the regulated area during the last four seasons are given in table 3.

TABLE 3.—*Citrus fruit produced, sterilized, and processed, and infestations of Mexican fruitfly in regulated area of Texas, 1943–46*

| Fiscal year | Fruit produced | Fruit sterilized | Fruit processed | Infestations |
|---|---|---|---|---|
| | *Boxes* | *Boxes* | *Boxes* | *Number* |
| 1943 | 19, 571, 400 | 584, 845 | 7, 339, 680 | 291 |
| 1944 | 21, 299, 760 | 1, 559, 957 | 8, 332, 920 | 576 |
| 1945 | 26, 454, 600 | 1, 698, 525 | 9, 638, 388 | 225 |
| 1946 | 28, 218, 816 | 2, 977, 000 | 9, 644, 128 | 310 |

### PINK BOLLWORM QUARANTINE ACTIVITIES

#### CHANGES IN REGULATIONS

Effective May 23 and July 1, 1945, and February 4, 1946, the pink bollworm quarantine (domestic) and regulations were amended to include newly infested counties. Modifications making more stringent the conditions for certification of cottonseed for movement to points outside the heavily infested areas of the lower Rio Grande Valley for crushing were made effective July 5, 1945.

#### INSPECTION FOR PINK BOLLWORM

Upon inspection of the 1945 cotton crop in Texas, the pink bollworm was found to have spread to additional counties. Initial infestations

were found in Brown and Medina Counties, and infestations reappeared in Chambers, Harris, and Liberty Counties after more than 20 years' freedom.

However, inspections in the regulated areas of southern Texas showed (1) a marked decrease in degree of infestation in the lower Rio Grande Valley; (2) a general infestation in the Coastal Bend area apparently of about the same light degree as in the previous year except for Duval, Jim Wells, and Kleberg Counties, where infestation was heavier; and (3) continued light infestation in all southern Texas regulated areas not mentioned above. Infestation was extremely light in the Panhandle and South Plains areas of Texas. The situation in the El Paso Valley has taken an unusual turn, as infestation in Hudspeth County, which for years was very heavy, has become lighter, being not over one-fifth so heavy in 1945 as in 1943; on the other hand, El Paso County infestation in 1945 was about 60 percent greater than in 1943.

In the regulated part of Arizona a small area of considerable infestation was located in Maricopa County. Infestation in the regulated area of New Mexico continued to be extremely light. Intensive inspection of the quarantined area of Louisiana revealed no pink bollworms. All inspections in Florida, Georgia, Alabama, Mississippi, Arkansas, the nonregulated portions of Louisiana and Texas except as mentioned above, Oklahoma, and California gave negative results.

For the 1945 crop season a total of 35,735 bushels of gin trash were inspected in regulated areas as follows: Arizona, 8,839; Louisiana, 512; New Mexico, 501; and Texas, 25,883. A total of 56,173 pink bollworms were found, 586 in Arizona, none in Louisiana, 47 in New Mexico, and 55,540 in Texas. In the field 3,390,370 bolls, squares, and blooms were inspected in Arizona, Louisiana, and Texas; only 276 pink bollworms were found, all in Arizona and Texas. Laboratory inspection of 14,362 green bolls from the 1944 crop in Arizona and Texas revealed 1,259 bollworms, all in Texas.

Inspection of 34,961 bushels of gin trash from the States or portions of States outside the regulated areas—Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Oklahoma, and Texas—revealed only 9 pink bollworms, all from Texas. Of the 159,824 bolls, blooms, and squares inspected in the fields in Florida, Louisiana, and Texas, 197 worms were found in Florida and 22 in Texas. All the specimens found in Florida were taken from wild cotton. Of the worms found in Texas, 19 were from Chambers County and 3 from Medina County.

There has been no spread of the pink bollworm from wild cotton in Florida, because the infestation in such cotton continues to be kept low. With more adequate labor supply and favorable working conditions, the possibility of mature seed falling to the ground has been greatly reduced during the last two seasons by removal of most of the plants before fruiting occurred. Since the start of the program 16,831,210 wild cotton plants have been removed, of which 236,009 were removed this year; this is approximately one and one-third times the number destroyed the year before. It has been possible to intensify the program for removal of ornamental or dooryard plants, and thus make a more effective barrier zone between wild and cultivated cotton.

### 1945 CLEAN-UP PROGRAM HIGHLY SUCCESSFUL

The control program in effect for the 1945 cotton crop in the lower Rio Grande Valley met with excellent success, contributing factors being as follows:

1. Ideal weather conditions for quick maturing of the crop.
2. Availability of pickers, which made a quick harvest possible.
3. Early destruction of the plants following harvest. A State regulation set August 31 for beginning of cotton host-free period, whereas October 1 was the date for many years. Compliance was augmented and the work accelerated through the deposit by growers of $10 in escrow for each bale of cotton when ginned, this deposit available for field cleaning if the owner failed to destroy his stalks by the August 31 dead line.
4. Favorable weather for field clean-up while this work was in progress.

As a result of a cotton-growing period 65 days shorter than the previous one and a stalk-destruction deadline date of August 31, which was much earlier than any previous deadline, there was at least one less generation of the pink bollworm, and the number of larvae going into hibernation was extremely small. Further, any larvae that may have been forced into hibernation so early in the season had to remain in hibernation longer than the normal period if they were to emerge to infest the 1946 crop. Destruction of cotton plants by a specified time during the 1945 crop season was required in all counties under quarantine in southern Texas, and as a rule satisfactory results were obtained by early destruction of the plants. However, several counties on and near the coast were affected by tropical rains incident to a hurricane, and plants could not be destroyed on schedule as the fields were covered with water.

A program was inaugurated in June 1946 to control the pink bollworm by applying DDT dust to the most heavily infested areas of the lower Rio Grande Valley of Texas and Mexico.

In an effort to reduce infestation in the area in Arizona showing an increase in pink bollworms in 1945, growing of stub cotton in 1946 was prohibited, and the State, Bureau, and growers cooperated to remove stub plants.

A total of 762,646 bales of cotton were ginned at 580 gins under dealer-carrier permits in Texas, New Mexico, Arizona, and Louisiana; 328,807 tons of seed were given the heat treament; 283,323 tons of seed were processed at the 44 designated oil mills; and 21 compression plants compressed 812,819 bales of lint and 2,245 bales of linters. A total of 5,200 bales of lint and 3,251 bales of linters from Mexico were vacuum-fumigated. At the two road stations maintained to inspect highway traffic from the quarantined area in the lower Rio Grande Valley, 223,322 cars and trucks were inspected, and 2,559 were found to be carrying contraband material, which was intercepted.

Cotton gins located in newly infested areas were equipped with cottonseed-heating machines, a total of 130 such installations being made. However, in the newly infested Trinity Bay area of Texas, where installations could not be made in time to heat seed from the 1945 crop, the Bureau sponsored a program whereby all seed on hand was heated to the required temperatures.

### COOPERATIVE WORK WITH MEXICO

Supervisory leaders and their staffs assigned for cooperative work in Mexico continued to aid the Mexican officials in their enforcement of pink bollworm regulations. These officials report definite and continued progress in connection with treatment of products by processing plants and improved sanitary practices at such plants designed to prevent the spread of the pink bollworm. Cultural controls adopted along the border are now being modified and adapted to areas in the interior of Mexico where this pest has been known to be prevalent. Practices of pink bollworm control in the two countries are constantly becoming more uniform.

### INSPECTION AT TRANSFER POINTS

During the year transit inspectors at 18 strategic transfer points examined nearly 2,000,000 shipments, moving via common carrier, to determine compliance with Federal domestic plant quarantines. Of these shipments 1,496 were found to be moving in violation of regulations. In addition 35 shipments were reported as violations of the regulations governing the movement of plants into and out of the District of Columbia, and 472 reported to State officials as apparent violations of State regulations.

At Columbus and Crestline, Ohio, inspectors examined during July and August 2,055 carloads and 160,559 waybills covering carloads of produce from the heavily infested Japanese beetle area. Interceptions were made of 20 carloads moving in violation of the Japanese beetle regulations. Inspectors at Dallas, Houston, and San Antonio, Tex., reported 643 violations of the Mexican fruitfly quarantine from January through June.

On January 8, 1946, administration of the District of Columbia plant regulations was consolidated in the Division of Domestic Plant Quarantines. From January through June 1946, 49,418 plants involving 480 out-bound shipments were inspected, treated when necessary, and certified. During the same period 22,614 shipments consigned to the District by mail, express, or freight were inspected and passed as apparently free of insects or disease. One out-bound shipment was refused certification, and five in-bound shipments were returned.

### TERMINAL INSPECTION OF MAIL SHIPMENTS

Terminal inspection of mail shipments of plants and plant products under the procedure carried out in cooperation with the United States Post Office Department, authorized by the act of 1915, is maintained in Arizona, Arkansas, California, District of Columbia, Florida, Hawaii, Idaho, Minnesota, Mississippi, Montana, Oregon, Puerto Rico, Utah, and Washington. The States of Arizona, Arkansas, California, Florida, Minnesota, Mississippi, Montana, Oregon, and Washington have also availed themselves of the provisions of the 1936 amendment to the terminal-inspection act for the enforcement of State plant quarantines.

## FOREIGN PLANT QUARANTINE ACTIVITIES

### MARITIME PORT INSPECTION

The discontinuance of wartime restrictions on shipping and the resumption of world commerce materially affected plant-quarantine

enforcement at maritime ports. Ship arrivals increased 33 percent over those of 1945 to a total of 47,299, which is over 51 percent greater than the average of the 10 years preceding the war. During the year improved procedures for obtaining advance information on expected arrivals have been adopted, which make it possible to utilize personnel more effectively than in the past. The increase in shipping was accompanied by greater demand for plant-quarantine protection, both as to cargoes and to passenger lists. Work loads were further augmented by the arrival of increasing numbers of civilians by boat, as well as by the return of large numbers of troops from theaters of war. Clearance of the latter was greatly expedited through arrangements with military authorities whereby baggage was inspected and safeguarded prior to embarkation.

The record of ship inspections appears in table 4. The data given in this table do not include those for ships engaged only in Great Lakes trade.

TABLE 4.—*Number of ships arriving, inspected, and bearing prohibited plant material, fiscal year 1946*

| Origin | Arriving | Inspected | Bearing prohibited material |
|---|---|---|---|
| Foreign ports, direct | 33,707 | 33,239 | 6,566 |
| Foreign ports, via United States ports | 7,025 | 6,142 | 661 |
| Foreign ports, via Hawaii | 1,071 | 1,071 | 312 |
| Foreign ports, via Puerto Rico | 40 | 40 | 12 |
| Hawaii, direct | 3,840 | 3,840 | 834 |
| Hawaii, via United States continental ports | 198 | 198 | 7 |
| Puerto Rico, direct | 284 | 284 | 106 |
| Puerto Rico, via United States continental ports | 102 | 102 | 13 |
| United States ports, via Panama Canal | 1,032 | 1,020 | 71 |
| Total | 47,299 | 45,936 | 8,582 |

## CARGO INSPECTION

Importations of most plants and plant products increased substantially during the year. The totals were as follows: Fruits and vegetables, 11,401,239 containers, 50,787,219 bunches of bananas, 6,286,919 pounds, and 126,660 units; nursery stock and seeds, 79,234 containers, 267,636 pounds, and 3,308,552 units; cotton lint, bagging, and cotton products, 1,052,374 bales, 243,328 containers, and 72,338,921 pounds; fibers and cereals, 1,077,209 bushels, 67,092 containers, 2,164,186 pounds, and 63,796 dozen. In addition, a number of lots of restricted plant material were admitted at Canadian border ports where no plant-quarantine inspectors are stationed, through the cooperation of customs officers and the Canadian Department of Agriculture.

Not included in the foregoing totals were several million importations of restricted plant material over the Mexican border in such small quantities that no entries are required by customs and no plant-quarantine record is made of them. Each of these small lots was inspected before release, and their handling required a large outlay of inspector-hours, particularly at the larger ports.

### DISINFECTION

The increase in the volume of importations of restricted plant material brought about a corresponding increase in the amount of such material required to be treated under the supervision of inspectors and collaborators of this Bureau. The number of bales of cotton, linters, and bagging treated was 635,693, more than three times the number treated in 1945. The 16,696,713 pounds of cottonseed cake and meal treated was almost 18 times the amount treated the previous year. The continued effectiveness of steps taken to encourage the use of suitable packing materials for shipments of beverages was evidenced by the fact that only 10,008 cases of liquor with weevil-infested vetch contaminating the straw jackets around the bottles required fumigation. The 33,375,137 units and 6,267 containers of plants, cuttings, bulbs, roots, and other plant-propagating material treated, represent an increase of 1,668 percent over the volume of this class of material treated in 1945, which in turn was about 50 times greater than in 1944. A total of 29,338 samples of cotton lint and linters, 12,241 bales of broomcorn, 26,720 containers of chestnuts, cipollini, and pigeon peas, 1,800 pounds of miscellaneous seeds, and 5,389 lots of other miscellaneous plant products were fumigated or otherwise treated. Also requiring treatment were 4,184 lots of returned Army and Navy equipment. On many occasions it was necessary to safeguard dry ballast containing vegetable matter and plant pests. Supervision of the disposal of such ballast required many hours of inspectors' time.

### AIRPLANE INSPECTION

The problem of preventing the entry of plant pests by air continues to assume importance with the rapid postwar development of air commerce. During the year 58,631 airplanes were inspected at 45 ports of entry. This represents an increase of 28 percent over 1945, which indicates that military air traffic is being replaced by civilian traffic. It was necessary to provide plant-quarantine protection at 3 ports previously without this service, to meet the demands at other ports normally handling surface traffic, and to increase the staff assigned to airplane inspection at still other ports. Prohibited plant material was taken from 12,156 of the airplanes inspected. That greater pest risk is associated with peacetime traffic is illustrated by the fact that this represents an increase of 66 percent over 1945 while, as noted above, the number of arrivals increased only 28 percent. Much of the prohibited material was of tropical or subtropical origin, which emphasizes the importance of plant-quarantine clearance of aircraft from abroad, particularly since most of the material was found on planes landing in the southern portion of the United States. Insects on planes arriving at ports where conditions are not favorable for their survival could easily be transported to such an environment within a few hours if they were not intercepted.

A total of 3,368 interceptions of insects and plant diseases were made from airplanes in 1946. While many of these pests, including mosquitoes, were stowaways that might menace public health,

plant pests of economic importance were found in plant material carried in baggage, cargo, mail, and stores. Among the insects found were a whitefly (*Aleurothrixus myrtaci* Bondar), the pink bollworm, the olive fruitfly, the Mediterranean fruitfly, the Mexican fruitfly, the West Indian fruitfly, and three other species of *Anastrepha*—*serpentina* Wied., *striata* Schin. (?), and *A. suspensa* (Loew). Among the 237 interceptions of plant diseases, 48 were on orchids, 45 on miscellaneous flowers and other ornamentals, 66 on rice, 10 on citrus fruits, and 62 on miscellaneous food plants. These figures, showing a substantial increase over former years, emphasize the growing importance of the airplane as a rapid disseminator of pests between countries and even continents.

### FOREIGN PARCEL POST INSPECTION

Parcel post from members of the armed forces abroad arrived in unprecedented volume during 1946 and presented an even greater problem in providing plant-quarantine protection than in preceding years. The danger of plant pests gaining entry by this means was increased by the relaxation of censorship, which had formerly served to enforce Army and Navy directives against the inclusion of objectionable plant material in service mail. The responsibility for protecting our agriculture against the entry of pests in mail from members of the armed forces, as well as other classes of foreign mail, now rests almost entirely on the plant-quarantine service. To furnish this protection, inspection was provided throughout the year at all the principal ports where such mail is handled by the customs. A total of 8,161,717 packages were examined, an increase of approximately 168 percent over 1945. Of these 2,882 were refused entry, in whole or in part, because they contained prohibited plant material, 5,026 were diverted to another port for disposition, and 9,583 were released under permit.

### MEXICAN-BORDER SERVICE

The number of inspections of freight cars from Mexico was decreased in 1946 to 62,076 from 64,995 for 1945. Despite this small decrease, the number remains at nearly twice the prewar level. The continued large volume of railway freight from Mexico is due to the fact that the heavy wartime movement of metals and other strategic materials is being replaced by other commodities, many of which require plant-quarantine inspection. It was necessary to fumigate 9,007 of these cars, as compared with 9,251 in the preceding year. The sales, at $4 each, of coupons valid for the fumigation of a freight car, amounted to $35,848. The number of necessary fumigations was kept to a minimum through the employment of procedures for waiving fumigation when it could be done without risk of pest entry.

In addition, 4,289 pullman and passenger coaches were inspected upon entry into this country, a decrease of 20 percent from 1945. This decrease was a result of the curtailment of the program to import laborers from Mexico which was instituted during the war. A total of 5,789,244 other vehicles and 1,282,566 pieces of baggage was exam-

ined in cooperation with customs officials, representing increases of 22 and 38 percent, respectively.

### INSPECTION IN HAWAII AND PUERTO RICO

In Hawaii the problem of preventing the introduction of foreign plant pests and the spread of injurious pests to the mainland was made more difficult by the rapid growth of air commerce. As in former years, the predominant activities in the enforcement of Federal plant quarantines governing the movement of plants and plant products to the mainland were preflight inspection of aircraft and the inspection of mail, baggage, and express. A total of 9,047 commercial and military airplanes were inspected prior to departure for the mainland, an increase of 9 percent over 1945, and there was a corresponding increase in the number of pieces of airplane passengers' baggage examined. There was a slight decrease in the number of pieces of baggage on surface vessels and in the volume of mail and express packages inspected. The return of large numbers of troops from the Pacific theater reduced the volume of Hawaiian mail inspected on the mainland. Late in the year arrangements were made to take over disinsectization of aircraft arriving in Hawaii from abroad, in order to safeguard against the introduction of plant pests which might be carried on them.

Greatly expanded air traffic also had a marked effect on plant-quarantine activities in Puerto Rico, as evidenced by the fact that, at the close of the fiscal year 1946, 22 commercial air lines were operating between Puerto Rico and the mainland. Emphasis continued to be on the inspection of aircraft and surface vessels to prevent the entry of foreign plant pests and the spread of injurious Puerto Rican pests to the mainland. Insular inspectors, acting as collaborators of the Bureau, assist in this work. In the latter part of the year there was a revival in shipment of fruits and vegetables to the mainland, an activity which was at a standstill during the war.

### INSPECTION OF DEPARTMENTAL PLANT MATERIAL AND OF PLANT-INTRODUCTION AND PROPAGATING GARDENS

In 1946 a total of 427 shipments of plant material, imported by the United States Department of Agriculture for scientific or experimental purposes, were examined during the year, and treated if necessary, at the Washington, D. C., inspection house. Such exotic plant importations, after inspection, are grown by the Department for a period in detention under quarantine conditions. Frequent inspections of this growing material were made to determine whether any pests were present which were not eliminated at the time of entry. These plants and their progeny are not released for distribution or propagation until determined to be apparently pest free, and final inspection prior to dispatch was made of 1,580 outgoing shipments of departmental plant material in this category.

Plant material being propagated at plant-introduction and propagating gardens maintained by the Bureau of Plant Industry, Soils, and Agricultural Engineering is inspected regularly for the presence of plant pests. Such material distributed from the gardens at Coconut

Grove, Fla., and Mandan, N. Dak., was inspected by State officials cooperating with the Bureau of Entomology and Plant Quarantine. The inspections at Chico, Calif., were handled jointly by an inspector from this Bureau and an entomologist from the California Department of Agriculture. Material distributed from the District of Columbia, Maryland, and Savannah, Ga., stations was examined by Bureau inspectors. The following were examined prior to distribution from these stations in 1946: 9,108 plants, 5,186 bud sticks and cuttings, 1,978 roots and tubers, and 1,332 shipments of seeds.

### INTERCEPTIONS OF PROHIBITED AND RESTRICTED PLANTS AND PLANT PRODUCTS

The interceptions of prohibited and restricted plants and plant products in 1946 were as follows: In baggage, 73,214; in cargo, 410; in mail, 3,648; in quarters, 9,031; in stores, 11,498; total, 97,801, an increase of 43 percent over 1945. Additional interceptions were made by customs officers at Canadian and Mexican border ports where traffic conditions do not warrant the services of a plant-quarantine inspector.

The excellent cooperation of other governmental agencies, particularly the Customs Bureau, in the enforcement of foreign plant quarantines, has been of great assistance to this Bureau in preventing the entry of pests. The Army and Navy contributed immeasurably to this program by issuing directives and employing safeguards to prevent the entry of potential pest-carrying material by troops and with military equipment returned from theaters of operations.

### PESTS INTERCEPTED

During inspection of foreign plants and plant products, together with such products received on the mainland from Hawaii and Puerto Rico, inspectors and collaborators of the Bureau collected insects belonging to 1,083 recognized species and others distributed among 852 genera and families, as well as fungi, bacteria, nematodes, viruses, and algae belonging to 336 recognized species, and large numbers of other pathogens that could be referred to genus, family, or general group only, even though some were important plant pathogens. Still others of this group were primarily of scientific interest, including a number of undescribed species not heretofore represented in the Department's collections.

The combined total of 58,303 interceptions of insects and diseases were taken as follows (figures refer to number of interceptions): In material offered for entry for consumption, 25,209 insects and 13,949 diseases; in material offered for entry for propagation, 10,630 insects and 2,737 diseases; in material not offered for entry, such as in-transit shipments and material in ships' stores, quarters, etc., 3,854 insects and 1,924 diseases; total 39,693 insects and 18,610 diseases.

### CERTIFICATION FOR EXPORT

A total of 3,823 export certificates covering 1,483,508 containers were issued to meet the sanitary requirements of foreign countries, representing increases of 74 and 72 percent, respectively, over 1945. Certificates were issued at 24 ports covering 48 commodities which were exported to 80 foreign countries.

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